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APPLICATION OF CHEMISTRY TO THE INDUSTRIAL ARTS

VOL 5 Fourth Series

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A MONTHLY RECORD of the PROGRESS of CIVIL and MECHANICAL ENGINEERING

ESTABLISHED 1843.

EDITED BY PETER SOAMES A.K.C. A.I.C.E.

PUBLISHED MONTHLY.

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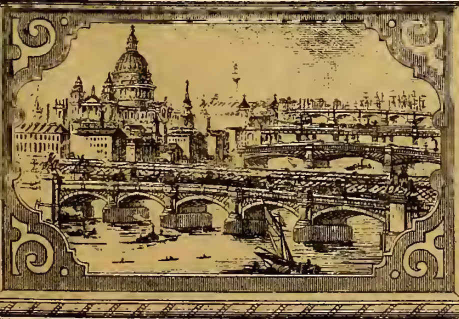

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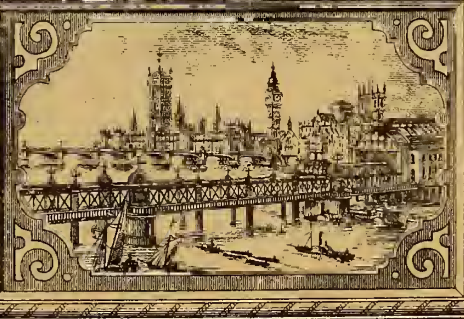

THE ARTIZAN:

A MONTHLY RECORD OF THE PROGRESS

OF

CIVIL AND MECHANICAL ENGINEERING,

SHIPBUILDING, STEAM NAVIGATION, THE APPLICATION OF CHEMISTRY TO THE INDUSTRIAL ARTS,

&c., &c., &c.

EDITED BY PETER SOAMES, A.K.C.,
Assoc. Inst. C.E., M. Inst. M.E.

Vol. V.,
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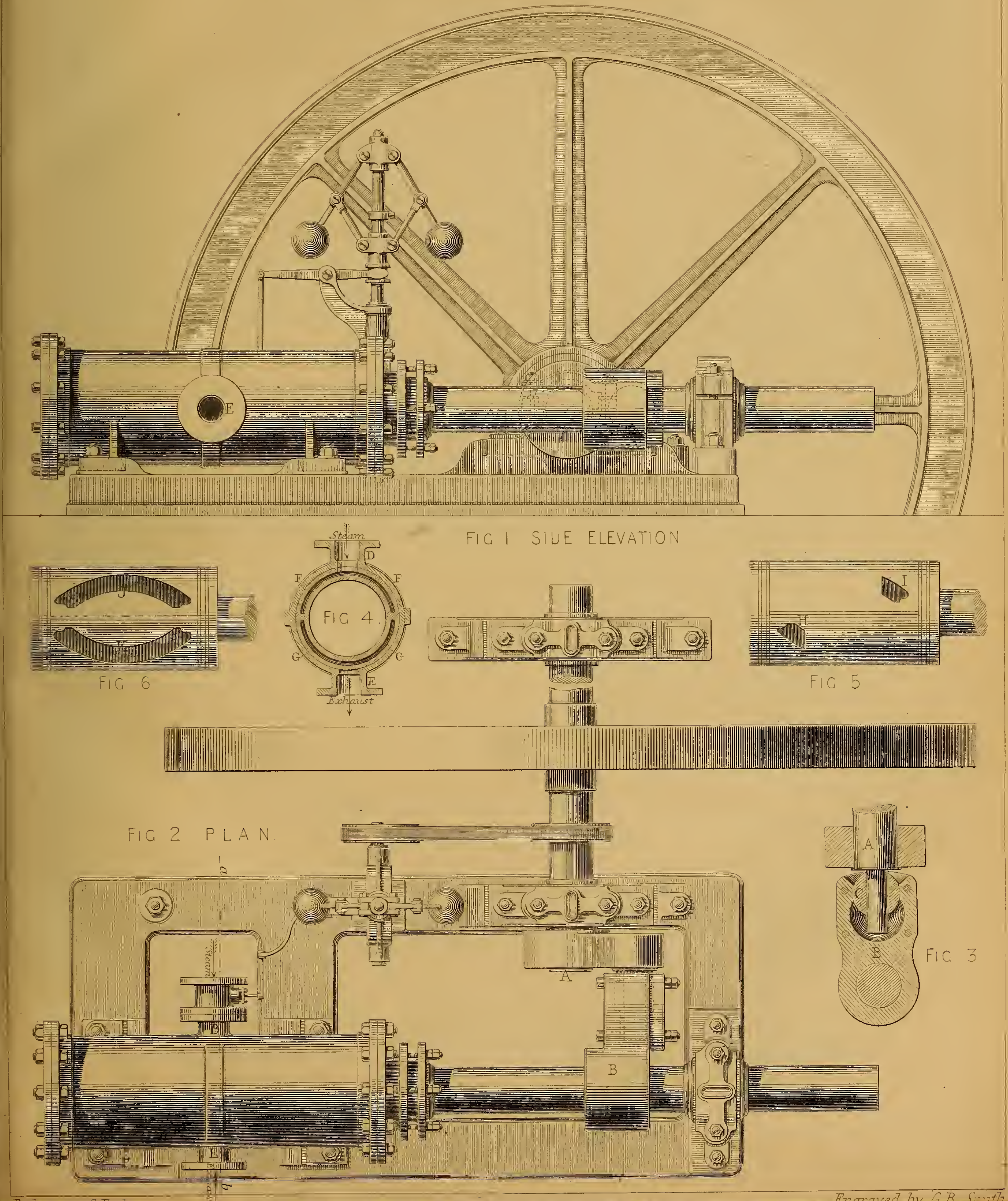
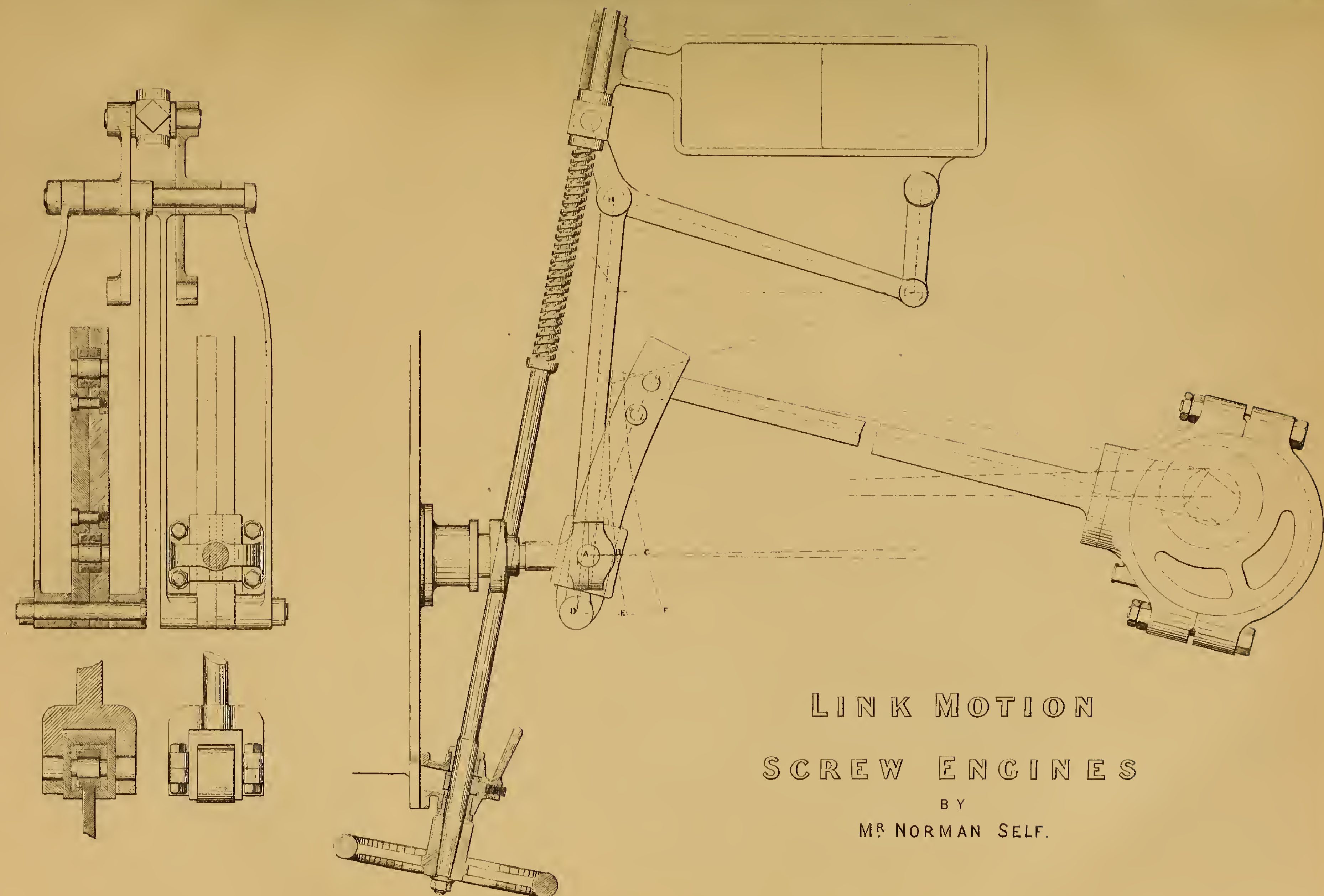


FIG 1 SIDE ELEVATION

FIG 2 PLAN.

Engraved by G.B. Smith



LINK MOTION

SCREW ENGINES

BY

MR NORMAN SELF.

P. Soames, A.K.C. dire.

THE ARTIZAN.

No. 1.—Vol. V.—Fourth Series.—Vol. XXIX. From the Commencement.

1st JANUARY, 1871.

ADDRESS TO OUR READERS.

After having had the pleasure of writing The Artizan Address for the last three years, we trust our readers will kindly excuse a momentary reference to personal matters. It is simply to inform them that having purchased the copyright, and also assumed the editorship of this Jonrnal, we intend in future to increase the number and interest of the illustrations and original articles hitherto contained therein. We have already made arrangements for that purpose; but, at the same time, we may remind our readers that any descriptions and drawings of new inventions or designs, if suitable to the pages of The Artizan, will as usual be heartily welcomed.

The disastrous effects of the bursting of the limited liability bubble in 1867 have, contrary to our anticipations, continued to be felt up to the present time, and consequently scarcely any engineering project of importance, however good the prospects may have appeared, has fonnd favour with investors.

Of the few important engineering works that have been completed this year may be mentioned the Thames Embankments. The opening of the Albert Embankment, ou the southern side of the Thames, occurred too near the end of the previous year to be noticed in last year's Address. It is a fine substantial piece of work, and although the engineering difficulties to be overcome were not great, the rapidity with which the whole was completed contrasts most favourably with many similar undertakings. Thus, the Victoria Embankment, on the northern side of the Thames, which was commenced many years before, was only supposed by the Board of Works to be opened in July last. We say "supposed," as we consider that in its present state it still requires a powerful strain on the imagination to believe that it is nearly completed: both the roadway and the foot pavements being in a very unfinished state, and in wet weather almost impassable. Moreover, until the completion of the new street to the Mansion House—the date of which appears about as far off as ever—it leads nowhere, and it cannot therefore be said, in its present state, to be either useful or ornamental.

In submarine telegraph engineering unusual activity has been displayed during the year, and contracts have been made—some of which are already completed—which will bring England into immediate communication with almost every important commercial city in the world. Amongst those already completed may be mentioned the British Indian Telegraph from Snez to Bombay—a distance of about 3,600 miles—which was successfully laid last March, thereby completing the line of communication between England and India. Besides the immense importance in a political and commercial point of view, the laying of this cable is peculiarly interesting as illustrating the advance made in this branch of engineering. The necessity for telegraphic communication with India was long since acknowledged, and many of our readers will doubtless remember the efforts that were made, about fifteen years ago, to submerge a cable along the Red Sea. At that time, however, in spite of the most strenuous efforts to accomplish this object, backed np by the stimulns of a Government guarantee, it was, after several failures, pronounced an impossibility; and attention was thereupon turned towards effecting the communication by means of land lines. Since then the successful laying of the Atlantic cables, aud other long submarine lines—owing to the improvements in the manufacture of the cables themselves, and also of the paying-out gear—made it evident that, unless the bottom of the Red Sea was pecnliarly unfavourable, there existed no difficulty in runniug a line from Suez to Aden. The bottom was accordingly surveyed, and as no such peculiarity could be discovered, another attempt was made, which has proved entlrely successful. A short time afterwards the Falmouth, Gibraltar, and Malta telegraph was laid, thus completing the submarine line to India, measuring nearly 7,000 miles, at an expense of nearly two millions.

Since then we have had an account of the successful laying of a cable from Singapore to Batavia, and also from Singapore to Pęnang, while we daily expect to hear of the completion of the link between Penang and Madras. Thns it may be considered that from the commencement of this year nearly the whole of our Eastern possessions will be in direct telegraphic communication with Great Britain; and as the passage from Singapore to China may be reckoned as occupying about a week, the transmission of news from that important country will be considerably shortened. In addition to the lines enumerated above as having been already completed, wo may mention that the line from Singapore to Hong Kong and Shanghai, 2,640 miles in length, is expected to be laid next Jnne, and the line from Singapore to Australia (Port Darwiu), which is about 1,730 miles long, before the end of the year. As the Telegraph Construction and Maintenance Company have hitherto been remarkably punctual in the performance of their contracts, we see no reason to doubt that this year will see the Australian colonies and China in direct telegraphic communication with England.

Turning to the West, we find Sir Charles Bright busy connecting the West Indies and Central America with the United States, and thence *viâ* the Atlantic cables with Great Britain. Although the laying of these cables has not been accomplished with such uniform sneeess as those hitherto laid in the East, in consequence of the unpropitious state of the weather, which, from the absence of well-defined monsoons, cannot be calculated upon with equal certainty; yet the very difficulties thus encountered and overcome serve to prove that the art of cable laying has attained such perfection that the danger of an absolute loss is now very small.

Although the opening of the Suez Canal was noticed in our last Address, we may mention that since that time it has been so far improved as to admit of the passage of much larger vessels than was then anticipated, and we find that even the Peninsula and Oriental Company, who were apparently very doubtful abont the utility of the undertaking, have lately used it for several of their vessels. We think it is a pity that they do not send all their vessels *viâ* the Suez Canal, for, as we pointed out last year, the nuisance of changing at Alexandria, travelling through the desert, and re-shipment at Suez, is by no means a pleasant operation to most of their passengers.

In railway engineering bnt little has been accomplished during the past year, a few short, though useful, and in some cases important extensions of existing lines being the only work accomplished in this country. A full account of one of these exteusious, viz., that of bringing the Midland Railway system into London, was given in The Artizan of last May, since which time, with the exception of the hotel, it has been entirely completed. The St. Pancras Station is certainly a magnificent piece of engineering, and when the hotel is completed will be one of the finest sights in London. It was anticipated that when the traffic of the

Midland Railway was diverted from the Great Northern that a considerable diminution would be shown in the receipts of the latter; bnt such has been the extension of trade with the North, that notwithstanding this large diversion of the traffic, the weekly accounts, instead of falling off, show a slight increase.

Shipbuilding appears to be still confined to Scotland and the north of England, where, as our columns will show, a good business has been done; bnt, with the exception of a few Government orders, the Thames is still left out in the cold. The only event of importance connected with shipbuilding, we regret to say, has been the loss of H.M.S. *Captain.* In another place is given the report of the First Lord of the Admiralty npon this extraordinary case, but which, as far as we can judge, does not add much to our knowledge of the subject. We may, however, add that, although we have generally differed with the late Chief Constructor respecting his designs for ironclads, and have made some severe remarks respecting their qualities, we cannot see how he can in any way be made responsible for this terrible calamity.

During the past year the tramway system has been extensively revived, and as the present design appears to be free from the objections which were fatal to the old system, there is every reason to believe it will prove a success, althongh at present, owing to the incomplete state of the various lines, the calculations upon this head are very imperfect.

Railway accidents, although scarcely within the scope of this Address, have lately been so freqnent and so disastrous that we may, perhaps, be excused for momentarily reverting to them. The most fertile sonrce of these accidents appears to be the breaking of the single chain which usnally connects the goods waggons to one another. Now, it is a well-known fact that iron subjected to constant vibration has a tendency to gradually crystallise and, consequently, become brittle; it is an equally well-known fact that these coupling chains are snbjected to violent jerking strains every time a train is started; it is also believed that cold acts injuriously upon iron: therefore, when a coupling chain has been in use for a considerable time onght we to be surprised if, when the cold weather sets in, we have a crop of accidents of this nature? There is, moreover, bnt little doubt that the absolute block system, combined with an arrangement—such as Saxby and Farmer's—for actuating the station and distance signals by means of the point lever, so that it would be impossible for the signalman to give a contradictory signal would, in all probability, have averted several of these terrible disasters.

VALVELESS STEAM ENGINE.

By Mr. JAMES ROBERTSON, Glasgow.

(Illustrated by Plate 368.)

It is a very long time since we have had the pleasure of laying before our readers such a decided innovation upon the practice of engine building, as that illustrated in Plate 368, together with a modification of the same principle in the accompanying engraving. In fact, we had almost given up the idea that anything particularly new in that direction was possible, unless it were one of the absnrdities that are now and then proposed by non-practical men. Mr. James Robertson of Glasgow, who has brought out so many nseful inventions—amongst which his frictional gearing is perhaps the most nniversally known—has, however, given ns a novelty in steam engines, which at the same time appears to be both simple and practical. The inventor has for some time past been mannfacturing engines and steam pumps on this plan, examples of which, with vertical cylinders, may be seen driving the ventilating fans of Glasgow University, and driving the machinery in the inventor's own workshop; aud lately, when we examined his engine, it was working perfectly smoothly and steadily, and evidently doing its work well.

Plate 368 represents one of the forms of this engine now being manufactured numerously by Mr. Robertson. Tho example shown is a noncondensing engine having a steam cylinder 20in. in diameter, with a stroke of 2ft., and has been erected for Messrs. Eadie and Spencer at their new tube works, Dalmarnock Bridge, Glasgow.

It will be seen that this engine is a very distinct innovation among the forms of steam engines now in existence. It is extremely simple in its construction. There are no valves of any kind used, and no connecting rod required, so that apart from the governor which is of the ordinary coustruction, the only working parts are the piston and rod, the crank pin bush and crank shaft necks.

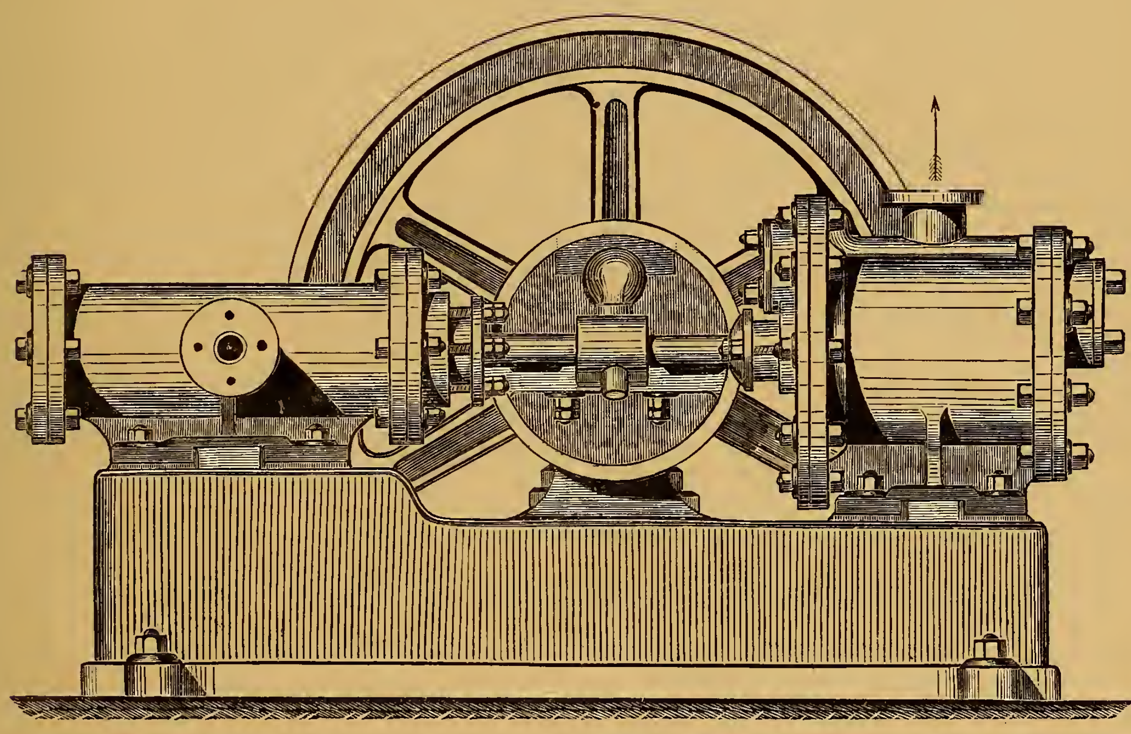
The piston and rod in large sizes, and in the example shown, are cast in one piece, the piston is somewhat longer than the length of its stroke, and in which the steam and exhaust passages are cast, the steam being admitted to and passed out of the cylinder throngh these passages in the piston. The piston is cored out internally and formed of two light concentric rings or cylinders, somewhat similar to an ordinary jacketted steam cylinder, the jacket space between these rings forming the steam and exhaust passages. The piston rod is also cast hollow to secure lightness and rigidity. The piston rod is connected to the crank pin of the crank A, by the arm B, keyed upon the rod, this arm B being fitted with a cylindrical crank pin bush C in this example flat on the ends, and bored ont in the direction of its diameter to receive the crank pin, secured in its position by a strong cover and bolts as shown. This cylindrical bush C, the form of which, with the arm B, is shown in sectional end elevation by Fig. 3, is left free to oscillate in its seat, and thus left free to accommodate itself to any position the crank pin and arm B may assume throughout the stroke of the piston. By this arrangement, the revolution of the crank prodnces an axial angular motion on the piston, as well as the ordinary longitudinal motion; every point on the piston surface thereby being made to describe an ellipse over a corresponding position on the internal surface of the cylinder, the major axis of which is the length of the stroke, and the minor axis the throw of the crank, or stroke reduced by the oscillating motion of the arm B, usually to about one-fifth part of the circumference of the circle of the cylinder. This peculiar motion gives excellent facilities for adapting the ports, or passages in the piston, to cnt off the steam instantly at any required point of the stroke, whilst at the same time it provides equally simple facilities for obtaining a free exhaust. The steam is admitted to the cylinder through the steam port D, and passes out by the exhaust port E as indicated by the arrows. The form of the piston will be seen by the sectional elevation of the cylinder and piston shown by Fig. 4. The section being given through the line *a b* of the ports D and E of the cylinder. The semi-annular spaces F and G in the piston being the steam and exhaust passages. Fig. 5 is a longitudinal plan of the piston and portion of the rod, showing the steam ports H and I, which in this example cut off the steam at one-fourth of the stroke. Fig. 6 is a similar longitudinal plan of the opposite side of the piston, showing the exhaust passages J and K. These passages pass opposite the corresponding ports in the cylinder, the steam being cut off by the short openings H and I in the periphery of the piston, as they pass across the steam port D of the cylinder, and a free exhaust is provided by the long passages J and K, the entire length of the stroke as they pass across the exhaust port E. The piston is shown packed by ordinary packing rings at each end, and is also provided with a longitudinal metallic packing between the steam passages, and a similar packing between the exhaust passages. Tho great length of the piston tends much to secure a perfectly steam-tight piston. The twisting motion also of the piston produces a smooth glassy face on the surfaces of tho cylinder and piston.

It may be objected that the piston-rod is very large, thereby occupying too much steam space in the cylinder, and also increasing the weight of the moving parts. But tho simplest calculation will show that the extra area thus occupied in the cylinder, bears a very insignificant proportion to the total area, while as the piston rod is cast hollow, the weight is scarcely, if at all, increased. The engine shown in Plate 368, and which, as has already been observed, was manufactured for Messrs.

Eadie and Spenoer, is provided with a Howard boiler, which is wrought at a pressure of 70lbs. to the sqnare inch, and works with all the economy in fuel due to the use of high pressure steam, and accurate expansive action.

Besides the simple high-pressure engine as shown in Plate 368, Mr. Robertson has arranged the same principle for condensing and for compound engines, and also for pnmping and blowing engines. For these pnrposes it is admirably adapted, and in the accompanying engraving we illustrate a blowing engine made some time since by him, which is also working most satisfactorily.

In this arrangement the air-pump is worked direct by the piston-rod, the air-pump piston being similar to the steam-piston, and thus no valves are nsed thronghont the entire engine. The crank-pin in this case is shown as working through a boss on the pistou-rod, bnt in some of the engines which we have seen the arrangement is somewhat different, the crank-pin being fixed to the piston-rod, and working through the ball socket in the crank or disc. The arrangement for expansion, whioh simply consists in shortening or elongating the curved slots in the piston, gives a very qnick cut off, and as the steam at the commenoement of the stroke acts directly against the ends of the cylinder, very little clearance is required. By this means the waste of steam in the steam passages nsnally incurred is reduced to a minimum.



From the above description we think our readers will agree with us in considering that Mr. Robertson's invention is not to be classed amongst the abortive schemes already allnded to, but that it is a decidedly practical and economical arrangement, and well worth the attention of users of steam power.

We hope on a futnre occasion to recur, possibly to these, or other special applications of these designs of engines, which promise so well, giving more definite results and particnlars of their economy and general working.

LINK MOTION.

Designed by Mr. Norman Selfe, Sydney, N.S.W.

(Illustrated by Plate 369).

Just a year ago, an illustration was given in The Artizan, together with an accompanying specification for a set of locomotive engines, which were in course of constrnction at Sydney. Since then, it appears that the engineers of New South Wales are not content with competing against the world in the manufacture of locomotives, but have turned their attention to iron ships and screw engines; for we understand that the Mort Dry Dock and Engine Company of Sydney are bnilding a screw steamer 190ft. in length and 22ft. 6in. beam, to be fitted with 36in. inverted cylinder engines. This, we believe, is the largest steamer as well as the largest iron vessel yet built in the Colonies, and as it is intended to be finished in the best style for passenger traffic, it will, when completed afford a fair standard of comparison with first class English vessels.

As the designer of the engines, Mr. Norman Selfe, could not be expected to be content with humbly following in the footsteps of English engincers, he has invented a new arrangement of link motion which is illustrated in Plate 369. It will be seen upon referring to the drawing that the link is of the class usually termed solid, only in this case it is formed in two halves bolted together with flush bolts and nuts. By this means the pins for the eccentrics are also contained within the body of the link, the ends of the eccentric rods being single instead of having jaws. The block is slotted throngh on the face nearest the crank shaft, of a snfficient width to allow the eccentric rods to pass between, so that when the valve is at full stroke the oentre of the pin of the driving eccentric is in line with the centre of the valve spindle. This is clearly shown in Plate 369, by the dotted lines drawn from the centre of the eccentric to the centre of the valve spindle, A and C being the position, of the centre of the eccentric pin at the top and bottom of the stroke

respectively, while B shows the centre position. It will also be seen that these three points are in a straight line; this being effected by means of the combination of rods, working on the common centre H, as shown in the engraving, acting as a parallel motion. By this means the wear is reduced to a minimum, as the moving power is always acting in a direct line. Another advantago is claimed for this arrangement, viz. that all the working parts are easily accessible, and can be re-bushed with very little trouble or expense.

From the above remarks, it will bo seen that mechanical talent is not confined to the northern hemisphere, but that the engineers of Australia are already endeavouring not only to compete with, but to surpass us in excellency of design. It remains, however, to be proved, whether they can also successfully compete with the workmanship and the prices of English engineers and shipbuilders.

DR. SEYFERTH'S PROCESS FOR THE PURIFICATION OF SYRUPS AND MOLASSES IN THE MANUFACTURE OF SUGAR.

The juices and liquors employed in the first extraction of sugar from the raw material it is contained in, as well as the syrups resulting from the sugar refining processes, all generally contain a certain quantity of alkaline substances, varying, however, in quantity with tho various conditions of the soil on which the beet-roots have been grown and the mode of cultivation. The juice of the ripe sugar-cane, however, is at the moment of beiug squeezed out of the caue slightly acid to test paper. By treating the saccharine juices with milk of lime, several of the bases of the alkaline salts present in the juices are separated from the acids they were at first combined with, and by thus being set free and remaining mixed with the sugar, impede its crystallisation. Ono part of alkaline matter can absorb as much as four parts of sugar; and some kinds of molasses (chiefly from beet-root) contaiu as much as 8 per cent of alkali.

The means hitherto tried to remedy this defect, viz., neutralisation of the alkalies by acids, have failed in practice, chiefly for two reasons—first, because the acids have not been applied at such a stage of the process of manufacture as to enable the acids to seize upon the whole of the alkalies; and secondly, because it has never been possible to prevent the injurious effect of even a very slight excess of acid upon the sugar itself; while, moreover, a difficulty is encountered by the very variable quantity of alkali present, whereby the proper quantity of acid to be applied varied every moment, thus rendering their application totally unsuited in any but very skilled hands. Among the acids applied sulphuric and phosphoric have been most used, but their use could not but be very limited, since even a very slight excess thereof was far more to be dreaded, on account of its highly injurious effects upon the sugar than almost any amount, so to say of alkalies. Sulphurous acid has been used and recommended in various forms, even as far back as 1810 (Proust), both on account of its activity as acid iu saturating alkalies, as well as its power as a bleaching agent, by thus rendering the sugar more white-coloured.

Dr. Auguste Seyferth, managing-director of the Brunswick sugar (beet-root) refiuery, has hit upon a plan for the use of sulphurous acid, which according to the nnanimous and unbiassed testimony of no less than 100 proprietors of establishments wherein the processes invented and bronght out by the Dr., since September, 1869, is applied, answers the purpose admirably, yielding more produce and of better quality in every respect. The process alluded to consists essentially in the introduction of snlphurous acid, either in gaseous form, or in very weak aqueous solution into the vacuum pans. By this arrangement it is possible to bring all particles of the sugar solution (syrup) into contact with snlphurous acid, and to eliminate, by the joint action of heat aud vacuum, any excess of that acid, which, however, not only satnrates free alkalies and carbonate of lime, but also sets the organic acids, which might be present as alkaline salts, free from these combinatious; the sulphurous acid taking hold of the bases they were combined with, while the greater part of these organic acids aro volatilised along with the steam and thus tho sulphurous acid promotes the good and ready crystallisation of the sngar, while its action as a decolouriser comes also advantageously into play.

The Seyferth process embraces two main operations, viz., tho manufacture of the sulphurous acid as gas, or as aqueous solution, and the application of the acid (chiefly in aqueous solution, being moro readily manageable) and its introdnction into the vacuum pans. The sulphurous acid is manufactured at the works (beet-root sugar mannfactories or sugar refineries) by the well-known expedient of burning sulphur in suitably constructed ovens, and carrying the products of combustion, previously cooled so as to condense any vapours of sulphur, into a leaden vessel wherein the gas is met by a suitably arranged current of water so as to become entirely absorbed. The aqneous solntion thus obtained is put into casks, or other suitable vessels, and from these a tube, provided with taps, leads to the vacuum pans, wherein the liquid is sucked simultaneously with the sugar solution. The party in attendance upon the boiling in the vacnum pans, while causing the sulphurous acid to be aspired, takes care to test from time to time (this is done by means of a contrivance technically known as proof-stick) the contents of the pan by applying blue litmus paper, so as to ensure the contents of the pan remaining alkaline; but if by a mishap the acid is in excess this is remedied by sucking in a fresh quantity of sugar solution, while a slight increase of the rapidity of evaporation (the turning on of more cold water to the condensers) will rapidly eliminate and volatilise any excess of sulphurous acid, which, when in quantities of 50 to 100 kilos. excess of the weak solution, docs not affect the sugar.

The quantity of sulphurons acid solntion applied varies from 4 to 8 or from 10 to 15 per cent of the bulk of liquid (syrup) to be evaporated but these figures are not absolute but only relative, siuce experience has already proved that the requirements differ for different localities. The process alludcd to is stated to possess, besides the advantages already named (productiou of better quality and larger quantity of sugar) the good qualities of being applicable at very little cost; to require no inconveniently large space; to be applicable to any already existing manufactory without causing any temporary stoppage of work; its application is readily learned by the sugar boilers. According to communicatious made on this subject by the members assembled at the general meeting of German sngar manufacturers and refiners, at Berlin (last May), and a similar meeting lately held at Pragne, this process is highly appreciated, and largely eulogised as an immense improvement in this branch of industry.

NEW JAPANESE MINT.

Following the example of Hong Kong, the Japanese aro about to have a mint of their own. It will be recollected that, some time since, Hong Kong built a mint, and fitted it up in first-class style, at a cost of over £100,000; and, but for that most conservative power called "vested interests," there is very little doubt but that the Hong Kong mint would have been a successfnl uudertakiug. However, it was stopped, to the manifest loss of the whole community, from the Straits Settlemeuts to Japan. The Japanese Government bought the machinery, and it was transferred to Osaka, and placed in a very handsome stone-cut building expressly constructed for the purpose, where tho operation of coining will commence in 1871. The new coiuage is to consist of gold 10, 5, and $2\frac{1}{2}$ dollar pieces; silver dollars, and 50, 20, and 5 cents; and copper 1 and $\frac{1}{2}$ cents., and 1 mil (this latter being probably the smallest modern minted coin). The dies were from Japanese designs, and were sent out from England; but, owing to the "reverse" in each case not proving very effective, some alterations thought judicious have been introduced. On the obverse of the gold coins will be the Japanese dragon in the centre, tied in an inextricable knot, surrounded by the value and date in Japanese. The reverse has in the centre the arms of Japan—tho round red "pellet"—above and below which are the flower badges of the Mikado. On either side of the arms are branches of the shrubs that bear the flower—emblems of Japan, and near the two "waveless" flags of the Mikado. The silver coinage is similar on the "obverse," but the "reverse" has the "pellet" in tho centre surrounded by rays towards the margin, in which the crests or badges of the Mikado appear with the wreaths before-mentioned. The copper coins are similar to the above, with smooth-skinned dragon instead of a scaly one. It will thus bo seen that the fancy of the Japanese for dragons and flags without waves has been fnlly indulged; while, at the same time, the coin will be handsome and striking, and far in advance of the Hong Kong mintage. With respect to the future working of the undertaking, the work before the officials is undoubtedly heavy, as a population of forty millions of people will have to be supplied; but the machinery is all of the best construction, and Captain T. W. Kinder is a man of considerable acumen, and has had some years' Eastern experieuce, having occupied a similar position at the Hong Kong mint. The melting department is furnished completely with the well-known manufactures of Morgan's "Pateut Plumbago Crucible Company," Battersea. Some regret is felt that the building is so far inland, and on such a dangerous river as is Osaka; Hiogo or Yokohama, therefore, would have been much more preferred as the site.

SHIPBUILDING FOR THE NAVY.

The following vessels are now under construction at the various places named, for Her Majesty's Navy:—*Arrow*, 1, double-screw iron gunboat, 245 tons, and 28-horse power, building by Messrs. Rennie, at Greenwich; *Blazer*, 1, double-screw iron gunboat, 245 tons, 28-horse power, at Portsmouth; *Blonde*, 27, iron screw frigate, cased with wood, 4,039 tons, 1,000-horse power, at Portsmouth; *Bloodhound*, 1, double-screw iron gunboat, 245 tons, 28-horse power, by Messrs. Mitchell, at Newcastle-on-Tyne; *Bonetta*, 1, double-screw iron gunboat, 245 tons, 28-horse power, by Messrs. Rennie, at Greenwich; *Bustard*, 1, double-screw iron gunboat, 245 tons, 28-horse power, by Messrs. Napier and Sons, Glasgow; *Comet*, 1, double-screw iron gunboat, 245 tons, 28-horse power, at Portsmouth; *Coquette*, 4, screw composite gunboat, 295, tons, 60-horse power, at Pembroke: *Cyclops*, 4, double-screw, iron armour-plated turret ship, 2,107 tons, 250-horse power, by the Thames Company, at Blackwall; *Devastation*, turret-ship, armour-plated, 4,406 tons, 800-horse power, at Portsmouth; *Fury*, 4, turret-ship, armour-plated, 5,030 tons, 1,000-horse power, at Pembroke; *Glatton*, 2, double-screw turret ship, armour plated, 2,709 tons, at Chatham; the *Gorgon*, double-screw iron armour-plated turret ship, 2,107 tons, 250-horse power, by Messrs. Palmer and Co., Jarrow-on-Tyne; the *Hecate*. 4, double-screw iron armour-plated turret ship, 2,107 tons, 250-horse power, by Messrs. Dudgeon, Poplar; the *Hydra*, 4, double-screw, iron armour-plated turret ship, 2,107 tons, 250-horse power, by Messrs. Elder and Co., Glasgow; the *Kite*, 1, double-screw iron gunboat, 245 tons, 28-horse power, by Messrs. Napier and Sons, Glasgow; the *Lively*, 2, paddle despatch vessel, 835 tons, 250-horse power, at Sheerness; the *Mastiff*, 1, double-screw iron gunboat, 245 tons, 28-horse power, by Messrs. Mitchell, at Newcastle-on-Tyne; the *Osborne*, 2, Royal paddle yacht, 1,536 tons, 450-horse power, at Pembroke; the *Raleigh*, 22, iron screw frigate sheathed with wood, 3,210 tons, 800-horse power, at Chatham; the *Rupert*, iron-clad ram, 3,159 tons, 700-horse power, at Chatham; the *Scourge*, 1, double-screw iron gunboat, 245 tons, 28-horse power, at Chatham; the *Snake*, 1, double-screw iron gunboat, 245 tons, 28-horse power, at Chatham; the *Thetis*, 13, screw-corvette, 1,322 tons, 350-horse power, at Devonport; the *Thunderer*, turret ship, armour-plated, 4,406 tons, 800-horse power, at Pembroke; the *Vigilant*, 2, paddle despatch-vessel, 835 tons, 250-horse power, at Devonport; the *Woodlark*, 3, double-screw gun vessel, 663 tons, 160-horse power, at Chatham.

THE LOSS OF THE "CAPTAIN."

Mr. Childers concludes his minute with the following observations:—

1. On the 24th April, 1866, the Duke of Somerset's board authorised Captain Coles to communicate with Messrs. Laird, with a view to that firm tendering for the construction of the *Captain*. Captain Coles was informed that, before parliament was asked for the requisite votes the design would have to be approved by the Admiralty; and with reference to that design the board laid down certain conditions as indispensable. Of these, one was that the ship should possess the sea-going qualities of a good cruiser. No reference, in this communication, was made to any responsibility for the design being placed on Captain Coles or Messrs. Laird.

2. On the 23rd July, 1866, the succeeding Board of Admiralty dealt with the design prepared by Captain Coles in communication with Messrs. Laird. Neither in the minute of that date nor in the letter of the following 10th August, was it distinctly stated that the design had been approved, or that the indispensable conditions laid down in the minute by the preceding board, dated the 24th April, had been complied with. But the board "approved of this ship being built, as proposed, on the entire responsibility of Captain Coles and Messrs. Laird," and laid down that their entire responsibility referred to "the design, the efficient construction of the ship, and the satisfactory accomplishment of their undertaking to complete her as an effective sea-going man of war.

3. It is clear that, whatever may have been contemplated by the previous board, and to whatever extent the approval, on the 23rd of July, of the ship "being built as proposed" was intended to express approval of the actual design, Captain Coles and Messrs. Laird accepted the entire responsibility for that design, and that the controller of the navy and his officers were for the time relieved from any responsibility as to the design.

4. It is also clear that, from first to last, both Captain Coles and Messrs. Laird were entirely satisfied that the *Captain* fulfilled the conditions on which she was built under their responsibility.

5. It is also clear, that as soon as the *Captain* was completed, and it became necessary to try her at sea, although the responsibility of Captain Coles and Messrs. Laird continued, and they could not be relieved from it until the ship's trials were over, yet the controller of the navy and his officers became responsible for the ship's fitness to go to sea; so that if they had reason to apprehend danger from her trials it was their duty to make representations accordingly.

6. It is also clear that no such danger was apprehended by the controller of the navy, or by any of his officers. Throughout the voluminous reports which were made by the controller, who watched her first trial at sea, the chief constructor, and his assistants, very little allusion was made to the question of the *Captain's* stability, and certainly no fears were expressed, or even hinted at, that she would be capsised from want of stability. Even when, during her fourth trial cruise, Mr. Barnes's first calculation of her curve of stability was before him, the controller of the navy saw no reason for any longer hesitating to accept the ship, or for communicating the calculation to the officers. I am aware that in his evidence before the court-martial the late chief constructor stated that "As soon as the news of the *Captain's* disappearance came to this country I concluded that she had capsized under the pressure of her canvas," and again, "I also knew that a friend of mine, an admiral in the service, took great pains to impress upon Captain Burgoyne that particular danger of her capsizing under her canvas to which reference has been made." I cannot, however, bring myself to believe that Mr. Reed's memory was accurate when he gave these answers. For if they correctly describe his anticipations, a heavy responsibility rests upon him in never having warned the controller of the navy of the danger he apprehended, and in having, on the contrary, recommended that the ship should be tried at sea.

7. It is also clear that the first sea lord, who is responsible to me for the instructions to ships in commission, was, in the absence of any such warning, fully justified in the orders, which he proposed to me, for the trials of the *Captain* at sea,

8. I am, at the same time, of opinion, that the experiment to ascertain the actual position of the centre of gravity should not have been postponed until just before the *Captain's* fourth trial at sea. The chief constructor had, in his report of the 2nd August, 1866, pointed out the risk of mistakes in this respect to which ships armed and plated like the *Captain* were liable; and when Messrs. Laird on the 24th February, 1870, requested that the experiment should be made, it was deferred by the controller of the navy, on the recommendation of the chief constructor, only until after the forthcoming steam trials, when an opportunity might offer and the weather was settled. Within a few days after Mr. Reed made that recommendation the error in the construction of the ship, bringing her about two feet deeper in the water than her design had contemplated, was formally reported upon and discussed in the constructive department. It is, therefore, in my opinion, to be regretted that no recommendation to the controller to take the experiment in hand was made be the chief constructor, who did not leave office until the following July; the first intimation received, either by the first sea lord or by me, of any such proposal, being a submission from the controller himself, dated the 20th of that month.

9. I am also of opinion that (irrespectively of Messrs. Laird's application for the determination of the centre of gravity) the late chief constructor ought to have recommended to the controller of the navy that the *Captain's* curve of stability should be calculated. No such recommendation was made by him either before or during her trials. I have referred in the present minute to the discussion, in 1867, of Mr. Henwood's proposal to convert the *Duncan* into a low freeboard fully-rigged turret ship, and to the objections which were made to such a ship on the ground of insufficient stability. In the controller's minute of the 9th. September, 1867 this element of danger was described as "requiring to be borne carefully in mind in all turret ships carrying sail;" and the paper by the late chief constructor on the stability of monitors under canvas, dated the 4th April, 1868, in which the diagram and calculation of the curve of stability were for the first time published, fully developed these objections; his conclusions being that "the danger to be apprehended to these monitors when under sail was very great" and that "monitors having their centres of gravity situated apparently like the centres of gravity of other ships would be quite unfit to carry canvas.' It is true that the *Captain's* freeboard was about 6 feet, and that she had a poop and forecastle, whereas the monitors, the subject of the discussion referred to, would have had only the protection of a freeboard of from 3ft. 6in. to 2ft. 6in. But considering that the lowness of the *Captain's* freeboard was one of the strongest grounds of objection to her raised by the chief constructor, I think it is greatly to be regretted that he never recommended this calculation.

10. I am also of opinion that it would have been better if, on the 23rd August, when Mr. Barnes's preliminary report (only giving the curve of stability for the *Captain* on the assumption of her poop and forecastle being shot away) was made to him, the controller of the navy had called the attention of the First Sea Lord and myself to it, and had recommended that it should be communicated to the officer in command of the ship, and to the commander in chief. The controller's minute of the 24th August, in which allusion is made to that report, gives no indi-

cation that it was otherwise than satisfactory to him, or that there would be any advantage in sending it to the fleet.

11. I wonld again refer to the appended papers which, at my request, the controller of the navy has prepared, explaining the reasons why the experiment as to the centre of gravity and the calculations of stability were not sooner made. There is great force iu some of the reasons given in this paper; but although unwilling, especially after the event, to express too decided a judgment upon questions open to so much donbt, I feel bound to state the opinions at which I have arrived.

12. I must however, add that, in my opinion, great allowance ought to be made for the anomalous position in which the minute of the 23rd July, 1866, left the professional advisers of the Admiralty. All responsibility for the design of a ship, to be built by a private firm, had been for the time taken from the constructive department and placed on the builders themselves, and the naval officer who selected and advised them. She was to be paid for as she advanced, on the certificates of that officer; and it was obviously necessary that her trials at sea should be carried out before he and the builders could be deemed free from their "entire responsibility." Yet the duty of the professional officers to report and advise the Admiralty, as to the fitness for trials at sea of tho ship, the design of which they had not approved, was left undiminished.

13. Whatever causes may have conduced to the loss of the *Captain*, I trust that this calamity will not prejudice the turret system, the establishment of which the country owes to Captain Coles, aud the success of which in other ships is undoubted.

14. I may add that with a view to obtain the best independent scientific and professional opinion on the receut designs of her Majesty's ships, I have adopted the eourse explained in the following memorandum:—

"The controller of the navy will be instructed to prepare a statement showing what, in the opinion of the constrnctor's department, as naval architects, were the faulty principles of the design of the *Captain*, and to what extent they contributed to her loss.

"Reports will be also called for explanatory of the constructive design of the *Monarch*, with respect especially to her greater or less security, as compared with the *Captain*.

"Reports will further be prepared relative to the designs of the *Invincible* class the *Devastation* class, the *Cyclops* class, the *Glatton* aud the *Inconstant* class, and as to what fnrther improvements can be made in those designs.

"My lords have determined to appoint a committee to whom these reports will be referred, and who will be requested to give their lordships the benefit of their advice and opiniou."

"In considering these reports the committee will advise my lords whether, with reference to the preseut state of the science of naval architecture and the requirements of naval warfare, the principles which should regulate the form and type of war ships to be built for this country, are fully satisfied by these designs, and by the improvements recommended in them, or whether any further modificatious are desirable.

"By the appointment of this committee my lords hope to give further effect to the policy which they adopted in 1869, when the designs of the new turret ships were referred for the opinion of a committee."

Let a copy of this minute with its appeudices, of the minutes of the court martial, and of the board minute thereon, be laid before parliament.

Hugh C. F. Childers.

TRIAL TRIP OF THE "HOTSPUR."

The *Hotspur*, 3, double screw iron armour-plated turret ship, built and engined by Messrs. R. Napier and Sons, of Glasgow, made the first official trial of her speed in the offing at Plymonth on the 16th ult., in charge of Capt. Charles Fellowes and Staff of the Steam Reserve. She is of 2,637 tons bnrden, and armed with a 25-ton Fraser gnn, monnted on one of Capt. Scott's carriages, on a turn-table inside a fixed turret, and with two 64-pounder rifled guns on the after deck. Her engines are horizontal direct-acting, of 600-horse power nominal, fitted with all the modern applianees, the cylinders of 64in. diameter, with 2ft. 9in. stroke. On this occasion the ship's draught was—forward, 19ft. 3iu.: aft, 20ft. 2in.; the barometer, 29·75; thermometer, 52; the wind, south-east; force, 4; the sea moderate, with southerly swell. Six runs were made on the measured mile, the resnlt giviug a mean speed at full power of 12·651 knots per hour, with mean revolutions 97·7 per minute; mean steam pressure, 26·5lb.; meau vacunm, 26·25in. The engines worked throughont in a most satisfactory manner; but after the full power trial had been completed it came on thick with rain, so that the marks could not be seen, aud the further trial at half power and circle turning had to be postponed. The trial was satisfactorily concluded the next day, when the following evolutions were performed, the ship's draught being the same as before, the barometer 29·98, thermometer 47·5, wind north, forch 1 to 4, sea smooth, with a long swell from sonth-west:— Ten circles were made at full boiler power, the first to starboard, with angle of rudder 35 degrees, the half cirele occnpying 1min. 53sec., the full circle 3min. 54see., the engines making 88 revolutions per minnte; the second to port, with angle of rudder 37 degrees; the half circle took 1min. 51sec., the fnll circle 3min. 47sec., with 85 revolutions per minute; diameter of each circle, 378 yards. The third circle, from rest, with starboard screw only, and helm hard astarboard, angle of rudder 37 deg; the half circle was made in 2min. 42sec., the full circle in 4min. 50sec., with 88 revolutions per minute; diameter of eircle, 290 yards. The fourth, also from rest, with port screw only, helm hard a-port, and same angle of rudder; the half circle took 2min. 37sec., the full circle 4min. 20sec., revolutions the same as last; diameter of circle, 250 yards. The fifth, with starboard screw only, and helm amidships; the half circle occupied 4min. 10sec., the full circle 7min. 40sec., with 96 revolutions per minute; diameter of circle, 580 yards. The sixth, with port screw only, and helm amidships; the half circle took 3min. 41sec., the full circle 6min. 41sec., revolutions as before; diameter of circle, 550 yards. The seventh, with starboard screw ahead and port screw astern, with all starboard helm (37 deg.), the half circle took 3min. 3sec., the full circle 5min. 29sec.; revolutions, 77 per minnte. The eighth, with port screw ahead and starboard screw astern, with all port helm (37 deg.); the half circle occupied 2min. 56sec., the full circle 5min. 28see.; revolutions the same as before. The ninth, with starboard screw ahead and port screw astern, helm amidships; the half circle was made in 4min. 36sec., the full eircle in 8min. 56sec., with 76 revolutions per minute. The tenth, with port screw ahead, starboard screw astern, and helm amidships; the half circle took 4min. 33sec., the fnll circle 8min. 41sec.; revolutions same as before. Two circles were made at half boiler power, the first with both screws and helm hard astarboard; the half circle took 2min. 37sec., the full circle 5min. 4sec.; revolutions, 67 per minute; diameter of circle, 420 yards. The second, with both screws and helm hard aport; the half circle was made in 2min. 8sec., the full circle in 4min. 22sec.; diameter of same, 380 yards; revolutions as before. Two runs were then made over the measured mile at full-boiler power with the port serew only which realized a mean speed of 10·07 knots per hour, with mean revolutions 102·45 per miuute; mean steam pressure, 29lb.; mean vacuum, 25·75in. Four runs on the mile were also made at half-boiler power with both serews, the result giving a mean speed of 10-601 knots per hour; mean revolutions, 79.53; mean steam pressure, 23lb.; mean vacnum, 26·75in. The extreme roll of the ship in the heavy swell during trial was from 15 deg. to port to 14 deg. to starboard.

INDIAN CIVIL ENGINEERING COLLEGE, COOPER'S HILL, SURREY.

Prospectus.

This college has been established at Cooper's Hill, Surrey, under the orders of the Secretary of State for India in Council, in view to the edncation of civil engineers for the service of Government in the Indian Pnblic Works Department. The system which it is in eoutemplatiou to pursue is described in the following regulations:—

2. Admission to the college will be obtained by competitive examination, to which all British-born subjects between the ages of seventeen and twenty-one years, and of sound constitution, who can produce satisfactory testimouials of good moral eharacter, will be eligible. Intending competitors will be required to furnish satisfactory evidence on these points to the Civil Service Commissioners, not later than the 20th May.* The college course will ordinarily extend over three years (subject to the exceptions stated in paragraph 18), and all the stndents who pass throngh it successfnlly will be appointed to the Indiau Public Works Department as assistant engineers, second grade—the salary of which grade is 4,200 rupees (about £420) per annnm—and will be provided with a free passage to India.

3. The competitive examination, which will be conducted under the orders of the Civil Service Commissioners, will embrace the following subjects:—

		Marks assigned.
(1) English composition	500	1000
History and literature	500	
(2) Mathematics, pure and mixed		2000
(3) Latin		1000
(4) Greek		1000
(5) French		750

* The needful forms of application, with instructions for filling them up, and as to the nature of the evidence required, may be obtained from the secretary, Civil Service Commissioners, Cannon-row, Westminster, S.W.

	Marks assigned.
(6) German	750
(7) Natural and experimental sciences, limited to not more than three of the four following branches; viz., (1), chemistry, (2), heat and light, (3), electricity and magnetism, and (4), geology and physical geography	750
(8) Mechanical (geometrical) drawing	500
(9) Freehand (figure and landscape) drawing	500

4. Of these objects two will be compulsory, viz.:—First, English composition to the extent of a candidate's being able to write grammatically and with correct spelling. Second, the following branches of mathematics, viz., arithmetic, algebra, geometry (first four and sixth books of Euclid), mensuration, and plane trigonometry, in which the candidate will be required to obtain not less than one fourth of the aggregate marks assigned to them.

5. A minimum of one fifth of the total number of marks allowed for each subject, except mathamatics, will be deducted from all marks gained by a candidate in it at the competitive examination.

6. The fifty candidates who, qualifying in the obligatory subjects, obtain the highest aggregate number of marks will be admitted to the college.

7. The entrance examination will ordinarily be held in July. The successful candidates will enter into residence in September. [But on the first occasion the examination will be held in June and the candidates will join in August.]

8. The college course will extend, as above stated, over three years, each divided into three terms, with vacations of four weeks at Christmas, two weeks at Easter, and seven weeks in the summer. The Easter term begins on the 15th January, and ends on the Wednesday next before Easter Sunday. The summer term begins fourteen days afterwards, and ends on the 29th July. The autumn term begins on the 16th September, and ends on the 18th December. [But on the first opening of the college the autumn term will begin early in August.]

9. An annual charge of £150 will be made for each student, in three payments of £50 per term, which must be paid in advance to the Accountant-General, Indian-office.

10. Of the nine terms into which the college course is divided it is intended that two terms at least in the third year, with the intervening vacation, shall be passed by the student under a civil or mechanical engineer, or partly under each. The fees to the engineers under whom the students are thus detached will be paid by the Indian Government, and an allowance of five shillings a day will also be made to the student for lodging money and in lieu of commons while absent from the college during term time.

11. The obligatory subjects of study at the college will be—mathematics, pure and applied, with the mechanics of engineering, civil and mechanical engineering, elementary principles of architecture, surveying, mechanical drawing, physical science, Hindustani and history and geography of India, accounts; the optional subjects taught will be—higher mathematics in extension of the obligatory course, physical science, ditto architecture, ditto freehand drawing.

12. The proficiency of the students in the studies pursued will be tested by periodical examinations, and by assigning values to the drawing, surveys, reports, &c., executed by them while at the college, as well as to the work done while detached under civil or mechanical engineers.

13. A certain minimum of qualification will be required in each of the obligatory subjects, as well as a certain minimum of average proficiency in all those subjects taken together, as tested by the aggregate marks gained; but students will be encouraged to pursue more particularly those branches of either the obligatory or voluntary course for which they may show special aptitude.

14. This qualifying standard of proficiency, as above defined, and as fixed for each year, is to be attained by the student at the end of the first and second year, failing which he will not be allowed to remain at the college.

15. A final examination will be held at the end of the third year in July. This final examination will also include Latin, Greek, French, and German as optional subjects, although no instruction will be given in them at the college. The whole subjects of examination will be divided into four branches, viz.:—First, engineering, including drawing and surveying; secondly, mathematics, including the mechanics of engineering; thirdly, physical science; languages, ancient and modern, including Hindustani and history and geography of India. The proficiency of the students will be recorded separately in each of these branches in order of merit.

16. All the students who attain the precribed qualifying standard at the final examination will be appointed to the public service on the terms already stated. They will be required to embark for India in the beginning of October following.

17. In the case of those subjects of which the required course may be completed by the end of the second year, the marks gained at the examination in that year will be carried forward to the student's credit in the final examination.

18. Although students will ordinarily be required to go through a three years' course, that condition may be dispensed with in the case of those who on admission shall satisfy the college authorities that they possess already a competent knowledge of the subjects taught at the college. Such students will be permitted to enter at once on the second year's course of instruction, and to qualify for the public service in two instead of three years. Similarly the third year's course of practical engineering may be dispensed with in the case of those who can show that they have already gone through an equivalent course. Students consequently who may be found entitled to both of these dispensations will become eligible for appointment to the public service after a single year's residence at the college, and this period may be still further reduced in special cases to a time sufficient to enable the student to go through the various exercises which form a part of the college final examination.

19. The system of instruction will be partly what is usually termed professorial, by delivery of lectures, and partly tutorial, that is, in supervision of and assistance given to the students in their work. There will be specified courses of lectures and times of instruction, at which attendance will be obligatory, but the professors and instructors in each branch will also give additional instruction to those who desire it.

20. It is intended that the college staff shall consist of the following officers:—The president, professor and assistant professor of engineering, professor and assistant professor of mathematics, professor and assistant professor of surveying, professor of physical science, instructor and assistant instructor in mechanical drawing, instructor in landscape drawing, lecturer in Hindustani and history of India.

21. Additional lecturers will be engaged from time to time for special subjects, as architecture, geology, &c., as well as examiners for the final examinations.

22. A laboratory and model-room will be attached to the college.

22. The sole responsibility for the discipline and management of the college and for the general superintendence of the studies is vested in the president.

24. The students will be distributed in sections, each containing from ten to twenty, under personal charge of one of the professors or assistant professors selected as tutor by the president, to whom the tutor will be responsible for exercising a certain degree of personal supervision over each student in his division, and for conducting ordinary correspondence with the student's friends.

25. Each student will be provided with a separate room furnished, and with fuel and light, also with the necessary attendance. He will be required to furnish his own linen, &c., for use in his rooms. Students will dine in hall. They may take other meals in their own rooms, certain fixed allowances being supplied as commons. Additional articles required will be supplied from the college kitchen at a fixed tariff, under such rules as may from time to time be made. Beer and wine can also be supplied at cost price from the college cellar.

26. The necessary provision will be made for the performance of divine service at or near the college.

27. Students will be required to wear academical costume under such regulations as may be prescribed by the president.

28. Students will be required to make their own arrangements for medical attendance when necessary, from persons approved by the president.

Particulars Regarding the Indian Public Works Department.

29. The engineer establishment of the Indian Public Works Department in which successful students in the college will be entitled to appointments, consists of the staff of engineers, military and civil, engaged on the construction and maintenance of the various public works undertaken by the State in India. According to the latest returns the staff comprises 896 officers, of whom 363 were military men and 533 civilians.

30. This branch of the public service is of comparatively recent origin, and its expansion has been rapid, the total strength of the department having been:—In 1840, 113; in 1850, 183; in 1863, 545; in 1867, 602; in 1868, 747; in 1869, 896.

31. The department is supplied from the following sources:—First, officers of Royal Engineers; secondly, other officers of the Indian army who have passed the qualifying examination; thirdly, passed students of Government civil engineering colleges in England and India; fourthly, civil engineers in practice of approved qualifications appointed direct by the Secretary of State or Government of India; fifthly, deserving subordinates promoted.

32. The head of the whole department is the Public Works Secretary to the Government of India, whose salary is 42,000 rupees per annum.

There are also four deputy secretaries, each in charge of one of the four branches into which the business of the department is divided; viz., buildings and roads, irrigation works, railways, and accounts. The whole expenditure controlled by the department is estimated for the year 1870-1 at about seven and a-half millions sterling, thus distributed:—

	£
Military works	1,488,208
Civil buildings	710,179
Irrigation works and embankments	2,388,953
Roads and miscellaneous works of public improvement	1,298,560
State railways	1,229,800
State outlay connected with guaranteed joint stock railways	359,860
	7,457,560

33. The various ranks of the department are as follows:—

	Salary per annum. Rupees.
Chief engineers—First class	30,000
„ „ Second class	24,000
„ „ Third class	21,600
Superintending engineer—First class	19,200
„ „ Second class	16,200
„ „ Third class	13,200
Executive engineers—First grade	11,400
„ „ Second grade	9,600
„ „ Third grade	7,800
„ „ Fourth grade	6,600
Assistant engineers—First grade	5,400
„ „ Second grade	4,200
„ „ Third grade	3,000
Apprentices	1,200

[*Note.*—Ten rupees are nearly equivalent in value to £1 sterling.]

34. There are usually two chief engineers in each province, one at the head of the roads and buildings branch, and the other of the irrigation branch of the department; but in the smaller provinces all the public works are under the superintendence of a single chief engineer. The Punjab Railway, the first of the new railways undertaken by the State, is under a separate chief engineer. According to the latest returns there were in all seventeen chief engineers for the twelve provinces into which, for administrative purposes, British India is divided, of whom six had charge of the buildings and roads branches, and five of the irrigation branches respectively of their provinces; five were chief engineers of smaller provinces, and one had charge of a state railway. Again, six of these chief engineers were in the first class, and the remainder in the second and third class. The chief engineer is also usually secretary to the provincial government in the public works department.

35. Each province or class of works within a province is divided into circles, under superintending engineers. The last returns show that there were altogether fifty-five officers of this rank in the department, of whom twenty-two had charge of circles of buildings and road works, twelve of circles of irrigation works or lines of canals, twelve of miscellaneous works, and nine of lines or portions of lines of state railways.

36. The superintending engineers are divided under the regulations of the public works code in equal proportions among the three classes.

37. The actual execution of work is conducted by the executive and assistant engineers. The sanctioned establishment of these officers, as well as of the higher ranks, varies from time to time, according to the requirements of the public service, but it is provided by the regulations that of the aggregate number maintained at any time the assistant engineers shall be 60 per cent. in excess of the executive.

38. Of the total number of executive engineers sanctioned for any province, it is provided that 3-16ths shall belong to the first grade, 4-16ths to the second and third each, and 5-16ths to the fourth. Of the assistant engineers attached to a province 1-3rd belong to the first grade, the remainder with the apprentices, to the other two.

39. Civil engineers appointed to the department from the new civil engineering college enter as assistants, second grade. They will either be placed at the disposal of the Government of India, and will be posted on arrival to one of the provinces under the administration of that Government,* or else they will be sent in the first instance to Madras or Bombay, in which case they will not be liable to transfer from those provinces.

40. Promotions from one grade or class to another are dependent on the occurrence of vacancies in the sanctioned establishment, and are regulated in the following way:

41. Promotions of their assistant and executive engineers in Madras, Bombay, Bengal, North-west Provinces, and Punjab, are made by the Governments of those provinces respectively, but the promotions of the officers of these classes serving in the seven smaller provinces are made from one general list by the Government of India.

42. Promotions to superintending and chief engineer are made on one general list for all India, except in Madras and Bombay, where the vacancies in all grades are filled up by the local government from the officers serving under them respectively.

43. Promotions is made wholly by selection; mere seniority is considered to confer no claim to it.

44. Further particulars regarding the regulations of this branch of the public service, as to leave, pensions, &c., will be found in an appendix to this prospectus, which can be obtained on application.

Appendix.

Extracts from the rules for the grant of leave of absence and pensions applicable to civil engineers in India.

Leave of Absence.

The following are the kinds of leave allowed—First, leave on medical certificate; second, leave on private affairs and furlough; third, privilege leave; fourth preparatory or additional leave.

9. Leave on private affairs and furlough will be granted by Government, or by authorised officers, on sufficient cause being shown, and when the concession of the indulgence may in no way interfere with the interest of the public service.

10. When an officer on leave in England is permitted by the Home Government to return to duty by a particular vessel, this permission, if necessary, will be held equivalent to an extension of leave until the arrival in India of the vessel on which the officer is permitted to return,

11. Leave on medical certificate, with allowances, must in no case exceed three years in all, and not more than two years may be taken at one time. Subject to these restrictions, leave within Indian limits may be granted, with allowances, on medical certificate, as often as sufficient cause is shown; but beyond Indian limits, such leave cannot be granted more than twice during the whole period of service. Should any further leave be applied for on medical certificate, it may be granted, but without any allowance. Preparatory leave counting as service towards pension can only be admitted in regard to two periods of leave.

12. Leave on private affairs and furlough, with retention of office, may be granted as follows:—Leave on private affairs—for six months in one period—which leave may be repeated after intervals of six years. Second, or a furlough—for one year after ten years' service, and a second furlough, also for one year, after eighteen years' service in India—such absence being limited to two years' during the whole period of service.

13. On taking leave under the preceding rule, for the first time, an officer must decide whether he will apply for leave on private affairs or for furlough, and having once exercised his option and obtained leave accordingly, he will not, during the remainder of his service, be eligible to the other description of leave.

14. Furlough, and leave on private affairs, taken in India, will reckon from the date of leaving office to the date of return thereto. Furlough, and leave on private affairs, taken beyond India, will reckon from the sailing of the vessel on which the officer embarks to the date of his return to India.

15. Furlough or leave on private affairs cannot be taken in continuation of privilege leave.

16. Privilege leave, when it can be granted without injury to the public service, and without additional expense to the State, may be allowed for not more than one month in each calendar year, to be taken either in one period or in not more than two instalments. Privilege leave may also be allowed to accumulate up to a limit of three months.

17. Privilege leave for one month in each calendar year may be allowed to officers who have not been absent on leave for eleven months immediately preceding, unless they took their last privilege leave in two instalments, in which case the indulgence will not be available until eleven months after the expiration of the first instalment, and six months after expiration of the second instalment of the previous year's privilege leave.

18. Preparatory or additional leave is allowed to officers proceeding to or from a sanatarium on medical certificate, or to or from the port of embarkation from India to Europe on private affairs, furlough, or medical certificate, and is limited to such period as the authority granting leave may think sufficient. Officers proceeding from presidency towns, on sick leave beyond sea, will be allowed fourteen days for preparation.

19. Officers retiring from the service on pension will be allowed fourteen days' leave on half-pay, provided the indulgence can be given without detriment or extra expense to the public service.

* Bengal, North-West Provinces, Punjab, Oude, Central Provinces, Burmah, Berar (Hyderabad), Mysore, Rajpootana, Central India.

Absentee Pay.

20. Absentee pay, if at half salary, shall in no case exceed 6,000 rupees, or £600 per annum; or if at one-fourth salary, shall not exceed £300 per annum. Within these limitations, absentee pay will be given as follows:—

I. To an officer absent on sick leave in or out of India, half salary for the first fifteen months of each period of absence (or, if the leave be taken in short periods in India, for the first thirty months taken from time to time, provided that half salary be not drawn for more than fifteen months at any one time), and one fourth salary during the remainder of his absence on allowance.

II. To an officer on leave on private affairs, one-half of his salary for a period not exceeding six months of continuous absence, and for any further period of preparatory leave which may be granted to him. But, if an officer absent on private affairs obtain an extension of leave on medical certificate, he will be subject for the whole period of his absence to the rules for sick leave.

III. To an officer proceeding on furlough whose salary does not exceed 200 rupees per month, one-half of his salary; provided, however, that it shall not exceed 800 rupees, or £80 per annum. If the absentee's salary shall be—

	Rupees.		Rupees.		Rupees.	£
Above	200	and not exceeding	400 per month	he may be granted an annual allowance of	1,300 or	130
,,	400		700 ,,		2,000 ,,	200
,,	700		1,200 ,,		3,000 ,,	300
,,	1,200				4,000 ,,	400

IV. To an officer on preparatory leave, one-half salary before commencement of other leave, and, on return from leave, one-half salary, one-fourth salary, or furlough pay, according to the rate of allowance he may then be drawing,

V. To an officer on privilege leave, full pay.

21. An officer who overstays privilege leave by not more than one month will forfeit pay for the period in excess; but, if he exceed his leave by more than one month, his office will become vacant. An officer on privilege leave who may resign the service or who may obtain sick leave without first rejoining, will, in the former case, forfeit his salary for the period of privilege leave, and in the latter case be subject to the rules for sick leave for the whole period of his absence.

Superannuation Allowances and Pensions—Allowances on Retirement.

6. On production by an applicant of such medical certificates as shall satisfy the Government under which he may be serving of his incapacity to serve longer in India he may be allowed—

I. Under fifteen years' service, a gratuity not exceeding twelve months' salary.

II. After fifteen years' service, one-third of his average salary (and of his personal allowance, if any) during the previous five years; provided, that in no case shall a pension be granted exceeding the sum of 3,000 rupees per annum, whatever the amount of salary, nor of 2,000 rupees per annum, if the salary shall not exceed 12,000 rupees per annum.

III. After twenty-five years' service, one-half of his average salary, (and of his personal allowance, if any) during the previous five years; provided, however, that in no case shall a pension be granted exceeding 5000 rupees per annum, whatever the amount of salary, nor exceeding 4000 rupees per annum, if the salary shall not exceed 12,000 rupees per annum.

7. After thirty years' service or upwards, a pension may be granted, without production of medical certificate, of the same amount and subject to the same limitation as that sanctioned for twenty-five years' service on medical certificate. This pension, as the reward of faithful efficient discharge of duty for thirty years, is termed a good service pension.

8. Pensions of the full amount authorised in paragraphs 6 and 7 are to be granted only as the reward of approved service. In any case in which an uncovenanted servant, without having incurred the penalty of removal from Government employ, shall, nevertheless, in the opinion of the Government under which he has been serving, not be entitled to the full amount of pension, the local Government will make such a reduction in the amount of pension as it shall consider just.

9. The foregoing rates of pension and gratuity are applicable also, without the production of a medical certificate of unfitness for service, to officers discharged on reduction of establishment.

Service towards Pension.

10. Dismissal for misconduct entails forfeiture for the benefit of past service.

11. Service as a substitute does not count towards pension.

12. Periods of service before the age of twenty-two, or of absence on other than privilege leave and preparatory leave, shall not count towards pension; nor shall preparatory leave be allowed to count as service if it is granted in addition to leave on medical certificate to an officer who has enjoyed leave of the latter description on two previous occasions.

13. The whole of the service in virtue of which pension is claimed must have been passed in an eligible grade and on a permanent establishment; but claims barred by this rule will be especially considered if the promotion from an ineligible grade was bestowed as a reward for meritorious service or for good conduct.

14. The period of service must be continuous; but, in case of the abolition of the office held by an officer, and his being subsequently employed by Government, his first period of service is to be taken into account.

Gratuities.

15. When an officer is discharged with a gratuity under these rules on reduction of establishment, the gratuity will not be given to him in one sum, but in monthly instalments of a month's pay until the full amount is paid. Should he be re-employed before or after the period for which gratuity is allowed, he will have the option of refunding the gratuity and recovering his former service, or of forfeiting that service by retaining the gratuity. In the latter case any balance of gratuity remaining undrawn at the date of his re-employment may be paid to him.

Payment of Pension.

16. Payment of pension will commence from the date on which the applicant cases to be borne on the establishment, or from that of his application, whichever may be the later date.

17. No pension shall be payable in arrear for a period exceeding six months, without the express sanction of Government obtained through the civil paymaster, unless the cause of the suspension of payment shall have been the neglect, order, or act of some public officer, and beyond the control of the pensioner, when the civil paymaster, on a reference being made to him, shall exercise his discretion in passing arrears for payment, or submit a representation of the case for the information and orders of Government, as he shall consider proper.

18. An officer shall. on retirement, have the option of drawing his pension either in India or from the Home Treasury. After exercising his option on retirement, he may, at a subsequent period, change the place of payment from India to England, or *vice versâ*. This change, can however, be allowed but once. The payments in England will be made at a rate of exchange which is annually fixed in communication with the Lords of the Treasury for the adjustment of transactions between the British and Indian Exchequers.

SOCIETY OF ENGINEERS.

THE THEORY OF SCREW PROPULSION.

By Michael Sefi.

A few words of apology may be necessary for writing on a subject which has been given up by many as hopeless, more particularly as it has been repeatedly stated that practical rather than theoretical investigation is required. The author proposes to deal exclusively with common screws, believing them to be, when well proportioned, as good as any other form proposed, and better than a great many. His object in bringing the paper before the society is to get elucidated, as much as possible, certain misty points upon which the theory of screw propulsion depends, and, in the absence of means to carry out experiments, to suggest a way in which those interested may be better prepared than they now are, to draw correct conclusions from any subsequent experiments that may be made; and a means of increasing the present knowledge of the action and results obtained from the screw propeller in ordinary practice by the simple statement, in a manner more lucid than that generally adopted, of the details connected therewith.

It seems to the author, from his little experience in matters connected with screws, that the general tendency is to attribute too great importance to the absolute area of the screw's circle of revolution, to the comparative exclusion of questions of pitch and area of blades and their relation one to the other. The ordinary method of computing the probable useful effect of any given screw from the area and velocity of the after stream is not only very rough but very incorrect, because by taking the area of the after stream by the square of its theoretical velocity as a measure of the thrust, or if the area of the screw's circle of revolution be taken and multiplied by the velocity squared of its theoretical progress due to the pitch, into the revolution per minute, we assume that the pressures per unit of area, the direction of those pressures, and their resultant, are the same throughout. This we all know is not correct. According to the most authentic experiments it has been shown that a portion of each blade varying between ·2 and ·3 of its total height from the

boss is comparatively inefficient. From a certain point in the blade dependent upon the pitch the useful effect of each unit gradually decreases until, where in contact with the boss, it becomes almost absolutely nothing, and that portion of the centre of the plane corresponding to the boss would of course represent a negative pressure. It must from this be seen that a calculation which omits these considerations is erroneous.

It may be said that multiplying by a coefficient would represent these differences, but it will be seen that this coefficient would have to be different in every individual case, except under conditions of exact similarity in all details.

The area of the blades of a screw may theoretically vary between 0 and $r^2 \times n$ (r being the length of a blade from the tip to the axis of the shaft), yet, *cœteris paribus*, the area of the screw's circle of revolution will be the same in both cases. But the lateral resistance caused by skin friction F will vary as the surface of the blade A ; therefore in the first instance $E = 0$, but in the second it is $= r^2 \times n \times c$, where c is a coefficient of hydraulic friction, varying approximatively as the velocity 1·7 and 1·8, consequently having an absolute value about as the 1·7 and 1·8 power of the distance of each particular unit of area from the axis of rotation. Again, supposing even that the area of the blades or that of their aft projection were uniform from boss to tip, as the angles vary continually the resulting useful effect of each infinitesimal portion must be different. It will, therefore, be seen that, the resistances varying with each detail, they cannot be conceived even with any approach to accuracy if grouped up and expressed in the ratio of pitch to diameter, as now is generally done. Another inaccuracy which ought not to be permitted is the following:—It is generally accepted that the blades should not have a greater aft projection than about one-sixth of the total plane of rotation. Accepting this, for the sake of argument, as correct, it ought to occur to those adopting it that the pitch of the screw will make a long difference in such area S in two screws of the same diameter. Let a = the angle of any part of the screw, with its plane of rotation, and x its aft projection : $x :: s : \cos. a :: 1 \therefore S \times \cos. a = x - \cos. a$ decreasing inversely as the angle, it ultimately vanishes, when S would therefore be infinite, and x nothing for the base of very coarse-pitched blades ; while, on the other hand, for the tips of fine-pitched blades cos. a may be made as near as we like = 1. The minimum of area denoted by the above expression is thus equal to one-sixth of the plane projections, while the maximum may be almost anything, the diameter, and consequent total area of plane of rotation, being in both cases identical.

Before proceeding further it will be necessary to say a word relative to the action and resistance of inclined planes moving in water. In calculating the resistance opposed by the water to such a plane in the direction of its motion, it is customary to suppose that the resistance varies as the sine^2 of the angle which it forms with its line of progress, upon the hypothesis that the resistance varies as the V^2 of the displacement of the water. An unit of area of the inclined plane in question is supposed at a given V to displace, to a distance equal to the length of the unit into the sine of its angle of inclination, a column of the fluid, having for its base the unit in question, and for its weight that of a column of water of the height due to the velocity of lateral displacement or to the lineal velocity of the plane × the sine^2 of its angle. Algebraically expressed, it will be $\frac{A \times (V \times \sin. a)^2 \times a}{2g}$, where A is the area of the unit in square feet, V its linear velocity in feet per second, and a the weight of a cube foot of water. This would be correct if the water were the moving body, because then the linear distance traversed by each particle in attaining a certain height on the plane would bear the proportion of 1 to the sine of a if so measured ; but when the water is at rest, and the plane in motion, the linear distance moved is then measured by what would be cos. a. Putting this distance equal to unity, the displacement becomes $= 1 \times \tan. a$. If this be true, it seems to the author that the resistance should vary as the tan. a^2. As an example, supposing that a plane be at an angle of 11 deg. 32 min. with the base, and consequently having a sine = ·1,9994, and giving an inclination of 1 in 5 nearly, disregarding friction, to draw any body when once put in motion at a certain velocity up said plane, the plane being at rest, would require a force = ·19994, of the weight of the body ; but if the plane be put in motion, and the velocity measured along its base, the body being only free to move in a line normal thereto, under the same conditions the dynamical force will equal W × ·20406 × V, ·20406 being the tan. of 11 deg. 32 min. Although applicable to solids, when considered with reference to water it appears to the author that a considerable modification is required. Supposing that the plane be moved along under the weight W, at any velocity V, the dynamical force P required, disregarding friction, = W × V × tan. a, but by doubling V it becomes W × 2 V × tan. a, the dynamical force varying as the velocity. In water W represents the pressure of the fluid upon the plane at any velocity V ; by doubling V, P becomes $= W^2 \times 2\ V \times \tan. a$. Consequently putting Q for the factor of augmentation of V, the resistance to the motion of an inclined plane in water would be as $W^2 \times Q\ V \times \tan. a$; or putting this in other words, if any given portion of an inclined plane be taken, having a relation of tangent to rad. as 1 is to 2, by moving that plane at a certain V in the direction of its base to a distance equal to its length, a resistance will be overcome, due to the displacement of a body of water equal to its superficial area, to a distance equal to the tangent of its angle. If a solid had been moved, a plane having a rise represented by 1 to 4 of base moved at twice the above velocity would do the same work ; consequently the power required will be that to overcome one-half the former resistance to twice the distance in the same time. If with respect to water the theory of the sine were correct, the resistance to the movement of the inclined plane might be arrived at in the same way, but the following results arrived at by Colonel Beaufort show that it cannot.

The following figures show the proportion borne by the effective resistance to that indicated by theory, which is represented by 1. At 30 deg. it was 1·1 to 1 ; at 19 deg. 28 min. it was 1·98 to 1; at 14 deg. 29 min. it was 3·24 to 1 ; at 9 deg. 34 min. it was 6·95 to 1.

As the theory of the sine ^{2} is nowhere near the truth, it is useless to admit it at all, and a solution of the question should be looked for elsewhere. What the author wishes to advance is that the resistance to all inclined planes may more correctly be expressed as some coefficients of the areas of their plane projection in the direction of motion into v^2 ; the theoretical would then come much nearer the practical resistance than as now calculated. In the example just quoted the area of the plane projection in the direction of motion being reduced by $\frac{1}{2}$, and the velocity increased by its reciprocal, the resistance varying as the simple power of the area, but as the square of the velocity, if it were a simple plane moving at right angles to itself the resulting resistance should be represented by $\frac{4}{2}$ of the former ; of course being an inclined plane it will be less. This is a very rough way of putting the matter, but it would give a better result than calculations according to the theory of the sine^2. In any case, however, it would be excessively difficult to arrive at a very close approximation of the total resistance of any inclined plane at a certain velocity, because experiments made by Mr. Colthurst and others some years ago show that greater pressure is encountered by the forward than the aft part of such planes moving in water. Two bodies were drawn by him through water at the same speed of 4·96ft. per second ; they were furnished with angular prows of the same inclination, viz., having a proportion of base to slant length of 1 to 3·3. One was constructed of exactly half the width of the other, and, being immersed to the same depth of 4½in., the latter presented double the surface of the former.

By the experiment it was found that the comparative resistances were as 1·89 to 2·51, or nearly 3 to 4 instead of 3 to 6, which would have been the result if the pressure upon each unit of surface had been uniform. The views advanced with respect to the resistance of inclined planes seems substantiated by the indifferent results derived from screws having excessively fine pitches and running at high velocities, and by the glaring incorrectness of the theory involving the sine^2, which was only found to be right at an angle of about 45 deg. In the author's opinion the parts of screw blades at this angle are for the following reasons doing the most useful work.

Water is equally mobile in all directions ; consequently, unless the pressure exerted upon its unit of area in all directions is equal, those portions subjected to the greater pressure will recede, which in the case of a screw is called slip, and this may be produced in one of two ways : it may either result from the water being carried round by the screw, or by its being driven aft. Whichever way the water is moved of course a loss results. In any portion of the blade of a screw the tendency to drive the water in one direction or the other might geometrically be represented by the sine and cos. of its angle of inclination with the plane of rotation ; and as these will always be one greater than the other, except at an angle of 45 deg., it follows that this angle ought to represent theoretically the inclination of a plane which would distribute the power exerted most uniformly upon the water. Practically, the angle might be something less than 45 deg., as friction would tend to carry the water round with the blades. If the pitch of the blades be uniform throughout, the angle of any part, with its plane of rotation, will of course be at its distance from the axis ; consequently, only one portion of the blade can be at 45 deg., and, if that be the most advantageous angle, the smaller the deviation made from it the better. To attain a minimum of deviation, it follows that this part of the blade should be situated about the middle of its length, as this would divide equally the disadvantages that would result from the coarser pitch consequent upon placing it higher (or nearer the tips), on the one hand, or those induced by the finer pitch consequent upon placing it lower on the other. This gives a pitch of about one and a-half times the diameter.

A few experiments, made entirely independently of this conclusion, during the regular working of two steamers running between Liverpool and the Mediterranean, showed this to have been the most advantageous pitch of any tried, other things being the same.

The following are a few details:—No. 1 steamer built of iron, in Hartlepool, in 1856:—Length, 210ft.; breath, 29ft.; depth, 16ft. to main deck, 7ft. spar deck above; draught loaded, 18ft. aft, 15ft. 10in. forward; carries about 1,100 tons total dead weight; cylinders, 42in. diameter, 30in. stroke; direct-acting inverted; jet condensers; greatest speed in smooth water, with all in perfect working order, nine knots; average on voyage with various weather and coal, seldom exceeds seven and three-quarter knots. Three-bladed iron screw, 12ft. diameter, 18ft. pitch; revolutions, under most favourable conditions, sixty per minute; average about fifty-seven; safety-valves loaded to 18lb., actual pressure varying between 13lb. and 16lb., seldom higher; vacuum, 24in., occasionally 25in.; consumption, 19 tons Lancashire coals daily.

This steamer was tried under exactly the same conditions subsequently with an ordinary screw of the same area and diameter, but having a pitch of but 16ft., and the result was that she fell off half a knot. The consumption increased to 20 tons per day, while the revolutions became sixty-eight. On another occasion she was fitted with a similar screw but having a pitch of 22ft. The result was that she only averaged six knots the whole voyage instead of seven and a-quarter, that is to say, fell off one and a-quarter knots fully, while the engines went only forty-eight to fifty revolutions per minute. The pressures carried were in each instance the same.

No. 2 steamer built of iron for same owners, in Hartlepool, in the year 1855: Length, 182ft.: breadth, 27ft.; depth, 14ft. 6in.; draught loaded, 15ft. aft, 13ft. forward; carries about 630 tons total dead weight. Engines, direct-acting inverted; cylinders 34in. diameter, 27in. stroke; jet condensers; vacuum, 26 and 27; best steaming in smooth water, eight and three-quarter knots; average on voyages, seven and a-half to seven and three-quarter knots. Screw, common, three blades; diameter, 10ft.; pitch, 14½ft.; revolutions, sixty-two. Consumption of Lancashire coal about 14 tons daily. Model of ship sharp and fine at ends. This steamer was afterwards tried with a screw of 13ft., same diameter pitch, but the results being unsatisfactory it was resolved to return to the original propeller. Two other steamers with which the author has had more or less to do, built two years ago, and fitted with screws of this pitch, are giving excellent results, as the following details, will show: They are sister ships in all respects, built almost simultaneously, and engined by one firm from the same patterns and drawings; but, like all sister ships, one seems to have a slight advantage over the other in point of speed, and one is a little addicted to priming, a vice that the other is free of. Their length is 270ft.; breadth, 31ft. 6in; depth moulded, 21ft. 4in.; draught forward, loaded, 16ft. 10in.; and aft, 18ft. 4in.; tonnage, 1,200 register. Screws, cast iron three-bladed, common type; diameter, 14ft.; pitch, 21ft.; length, 2ft. 2in.; total area of three blades, 59·88 square feet; area of plane projection, 153·93 square feet. Engines, direct-acting inverted, 36in. cylinder, 42in. stroke; weight on safety valve, 40lb.; ordinary working pressure, 25lb.; surface condensers, vacuum 26½lb.; revolutions varying between fifty and fifty-four; average speed about nine and a-half knots, but whole day's steaming, without any sails and a slight breeze ahead, have shown ten knots, or 240 to 245 miles per day. On trial trip the maximum speed attained was twelve and a-half knots, the engines making sixty-eight revolutions. A whole hour's continuous steaming showed twelve knots, with sixty-three revolutions. Average pressure, 29lb.; vacuum, 26lb.; draught of ship forward, 7ft. 3in.; aft, 14ft. 8in.

If the before-mentioned results go to prove that the theoretical deductions are justifiable the blade might well be made proportionately wider than ordinary at that part having an angle of 45 deg., and the tips narrower, as this allows for the greater development of the best portion of the screw, and for the utilisation of a greater portion of the available power in a more advantageous manner than would otherwise be the case. To this may certainly be attributed a portion of the improved results sometimes obtained by rounding off the tips of blades, and consequently reducing their area at the extremities; for, putting aside for the moment questions relating to the pressures induced by the passage of inclined planes at small angles to their line of motion through the water, which are not well understood, as the actual velocity of the outer parts of the blades is in every case, and more especially in that of fine pitches, considerably greater than the theoretical advance due to the pitch, and as the resistance in each direction varies about as the V^2, it follows that the lateral resistance due to friction increases much faster than the after thrust, and that the smaller the frictional surface the better. This, therefore, goes to show that the minimum of area of blades necessary for propulsion will be the best, and that fine-pitched screws, revolving at high velocities, are wasteful of power. The friction of water, unlike that of solids, does not depend upon any coefficient of absolute weight or pressure, but upon the velocity with which the body passes through it.

According to Professor Rankine, the frictional resistance R of clean painted iron ships is 1lb. per square foot at ten knots, varying as the velocity squared. According to Mr. Scott Russell this resistance is 1lb. per square foot per foot per second, also varying in the same ratio. Applying Professor Rankine's computation to any surface of any given area a, the frictional resistance in 1lb. becomes $= \frac{a \times V^2 \text{ (in knots)}}{100}$. When applied to a screw, as the friction will vary as the distance² of the part from the axis, it is necessary to divido the blades into spaces by ordinates K, say 1ft. apart, and the calculation becomes

$$a \left\{ \frac{\sqrt{(2 \pi r)^2 + P^2} \times x \times 60}{6082 \cdot 66} \right\}^2 \div 100 = F$$

nearly in lb., where P = the pitch of the screw, a = the area of the space enclosed by any two ordinates, K — x = number of revolutions per minute, F frictional resistance, r distance of centre of area enclosed by ordinates from the axis. And putting

$$a \left\{ \frac{\sqrt{(2 \pi r)^2 + P^2} \times x \times 60}{6082 \cdot 66} \right\}^2 \div 100 = S_1$$

the total resistauce in foot pounds becomes

$$\frac{\left(\frac{a\,1 \times S_1^2}{100}\right) \times r_1 + \left(\frac{a_2 \times S_2^2}{100}\right)}{K\,n} \times r_2 + (a\,n \times S\,n) \text{ \&c.}$$

The value of

$$\frac{A\,n \times S\,n}{100}$$

increases as r^2; consequently the dynamical force required to overcome it varies as r^3. From this it is easy to see how euormous the frictional resistance may be made by overloading a blade at the tips with surface.

The proportions of screw blades with respect to surface are in a more unsatisfactory state than that of any other question relating to screws. In practice the fault seems always to have been to err on the side of too much surface; consequently the limit of economical area has been reached and passed on that side, and the question that now remains to be determined is the limit of surface on the other side. The question of area seems to resolve itself into one of great surface, S_1 and small pressure, P per unit of surface, or one of small area and great pressure. The values of P and S, therefore, vary reciprocally, but both vary as r^2. The problem seems to be to determine the most advantageous value of P for the different radii. As every cubic foot of water abstracted from the stern of a ship represents an equal increment of pressure at the bows, tending to retard the speed, it follows that a small quantity of water reacted upon at high pressure is more advantageous than a larger quantity reacted upon at a low pressure point of area. Again, according to all authorities, frictional resistance increases about as the area into the V^2, or into the 1·8 power of the velocity; but according to the same, the pressure upon an inclined plane moving through water, although varying about as V^2, is not directly as the area, but varies in a smaller ratio. Therefore, after a certain width of blade has been attained, the useless resistance increases faster than the pressure due to the velocity.

With reference to Mr. Rigg's theory of inclined paddles, and repudiation of that generally accepted, of the propeller screwing its way through the water, they appear to the author, to a certain extent, reconcileable one with the other. The ordinary theory takes into consideration the effect of the action of the screw; Mr. Rigg's, the result of the effect or the deflection of the water by the blades. This seems, however, to have but little to do with the action of the propeller, as such water, after it has once passed it, has nothing to do with the propulsion of the ship. If the screw be supposed working in undisturbed water, the action would be about the same as that of any inclined plane acting in a solid body, the only difference being that the solid body retains its shape after the action, while the particles of water, being free to move in any direction, naturally follow the line of least resistance or greatest impulse. Summarising what the author has in the foregoing endeavoured to express, the following questions present themselves:—In any given screw, what should be the diameter, pitch, and area, and the position of maximum area? It being acknowledged by all that the diameter should be as great as the draught of the ship will allow, this is easily answered. As to pitch, the author hopes to have shown theoretically, and by such few experiments as have been available, that a pitch of one and a-half times the diameter is at least one of the most advantageous. The next point

is certainly the most misty. The maximum of area having been attained, the minimum should be determined; what this minimum may be it is excessively difficult to arrive at by inductive reasoning, the more so as it imports into the subject questions relating to the economical speed of the engine. Theoretically, area and velocity vary reciprocally; therefore, a reduction from a given area would have to be made up by an increase of velocity or *vice versâ*. It may perhaps be attained when the work done in driving the engine light at the velocity of the screw and loss in slip bears a minimum proportion to the total power expended in propelling the ship.

Lastly, the greatest width of blade. This should be in the most advantageous position, and if what has been said respecting planes at an angle of 45 deg. hold good in screws having a ratio of pitch to diameter as 1·5 to 1, it should be about the middle of the length of the blade. In screws of finer pitches it might be somewhere nearer the tips than the line of 45 deg., to avoid as much as possible the broken water left by the stern.

As a simple way of enabling a better judgment to be formed, and of increasing the existing very slight knowledge of the right proportions to be given to different screws, the author suggests that in the description of every such propeller as given by the engineers, instead of stating only the diameter and pitch, that the diameter of the boss be given, also that the blades be supposed traversed by ordinates 1ft., or in smaller screws 6in. apart, commencing from the tips of the blades, and that the length of each ordinate and its angle with the plane of rotation be stated.

As an example, he gives the following, which are details of the screws of the sister ships already alluded to :—

Pitch, 21ft. diameter; boss, 2ft.; ordinates, 1ft. apart.

1st	ordinate length	4·65ft.	angle	26	deg.
2nd	„	4	„	30	„
3rd	„	3·33	„	35	„
4th	„	3·	„	43	„
5th	„	2·65	„	54	„
6th	„	2·33	„	68	„

Consequently, as there are six ordinates to each blade, and 2ft. of boss, the diameter of the screw will be 14ft.

These dimensions are all easily taken in a few minutes from the drawing of the screw, or if only the lengths of the different ordinates be given they will show the width of the blades at the different portions, and the angles can easily be calculated from the pitch, either trigonometrically, or by geometrical construction. From this a comparative coefficient might perhaps be deduced about as follows :—

$$\sqrt{r_1^2 + r_2^2 + r_3^2 + rn^2} \times \left(\frac{S\,A}{n\,K}\right)\left(\frac{S\,\theta}{n\,\theta}\right)$$

where $\frac{S\,\theta}{n\,\theta}$ = sum of the angle divided by their number = the mean angle, and $\frac{S\,A}{n\,K}$ gives the mean area.

Even the most intelligent man might puzzle himself for an unlimited period with the meagre details ordinarily furnished, without being able to make anything out of them; so it is of great importance to the cause of screw propulsion that the above-mentioned system or something similar be adopted, more particularly because the immense expense of the experiments necessary precisely to determine what it is requisite to know, causes them to be deferred from year to year, while badly designed screws are being driven at a cost for fuel out of all proportion to the useful effect produced.

The author has proposed that the before-mentioned data be given by the constructors of screws and engines, in conjunction with other details of ship and machinery, and results obtained, as an approach to something definite, and as a step towards giving some criterion by which to judge of different screws. This was shown to be necessary in the beginning of the paper, in mentioning the incorrectness of grouping the resistances together in the simple terms of diameter, pitch, and velocity.

In writing the present the author has painfully felt the want of reliable unbiassed information, and the scantiness of the details noted on all occasions where screws are dealt with; and it is necessary to state that this paper has fallen considerably short of what was intended.

With reference to experiments, it would be of but little use to try them by driving propellers of different dimensions in the ordinary way, as they would only be like a repetition of those made in the years 1844-5 with the *Rattler* and the *Dwarf*, from which it seems comparatively nothing conclusive has been learned. On referring to an account of these experiments to ascertain the date, the author finds the following statement :—" The most favourable results were obtained from a double-threaded screw of 5ft. 1in. diameter and 8ft. pitch. During one experiment the length was 1ft. 6in., and the area 13·3 square feet, the speed attained being 8·94 knots; and it is remarkable that in the experiment following, when the length of the screw was reduced to 1·1ft., and its area to 8·9 square feet, there was comparatively little variation in the resulting speed of the vessel or screw, the speed attained being 9·11 knots. This was the best result of the whole series."

The reduction of area would, in the author's opinion, have given better results, but that cutting a blade away leaves very thick edges to bruise and lash the water about.

The screws experimented upon were all 5ft. 1in. in diameter; the pitches 8ft., 10·32ft., and 13·23ft.; and although the most advantageous area of 8·9 square feet was tried at all these pitches, that of 8ft., or about one and a-half times the diameter, gave the best result. Having arrived at the conclusions already expressed, without knowing the details of the *Dwarf's* experiments, the author merely quotes them in corroboration of the ideas advanced. In case of a further series being undertaken he proposes to the consideration of the Society that they be made somewhat as follows :—

That an ordinary screw, say, having two blades, and a diameter of perhaps 10ft., pitch 15ft., and length of 1ft. 6in., be cast and fitted to a shaft set up in bearings in a basin of a dock, with no more obstruction to the free run of the water than is necessitated by the bearings, &c.; this to be driven by an endless band from the shore by the most powerful and nearest engine available, if possible of not less than 180 to 200-horse power nominal. The screw first to be driven at a low speed, and its velocity afterwards increased, say, five revolutions at a time per minute, until the maximum driving power of the engine is reached. Each separate speed to be maintained for a space of time sufficient to observe and note the results in a reliable manner; the direction and pressures of the currents produced being measured by means of vanes or other suitable method. The resistance to turning to be measured by means of a dynamometer on each shaft, the proper allowance being made for friction at the different velocities. The thrust to be measured either under water or by means of a lever in contact with the end of the shaft, reacting upon a dynamometer in any convenient position.

Next, that four or eight (or as many as may be decided upon by those entrusted with the experiment) bosses exactly similar to that of the perfect screw be cast and fitted to the shaft, and tried separately at exactly the same number of revolutions as the screw, the first boss carrying portions of the blades up to 6in. or 1ft. from the boss (according to the number to be experimented upon); the second to carry 2ft., the third 3ft. of each blade, up to the fourth, which will form a perfect screw, having a diameter of 8ft. and a pitch of 15ft. The next 2ft. of surface will be represented on the perfect screw. The tips of each portion to be struck to the radius of the circle which they describe. If the resistances given by each at the different velocities be carefully noted, the increment of observed resistance can only be due to the increase of area.

It is evident that this method of experimenting might be extended indefinitely according to the inclination of the experimenters and the funds at their command; and the resistances due to each particular division of the blades, and their variation at different velocities, must be arrived at with a much greater degree of precision than would otherwise be possible. It might be advisable to cast the boss separately and bolt the blades and portions of them to the same in the ordinary way for screws with shifting blades, but as the suggestion is simply in outline it would be useless to occupy the time of the society with details. The author brings the above suggestion relative to future experiments before the Society, because although all agree as to the necessity for such experiments, no one seems to have any very decided idea of the particular way in which such experiments should be conducted; and in the author's opinion, if tried on a ship and propeller under ordinary circumstances, it would be difficult to know in what particular direction to look for the lessons to be learned, or to separate the reliable portion of the results attained from the influence of extraneous circumstances.

INSTITUTION OF ENGINEERS IN SCOTLAND.

INTRODUCTORY ADDRESS.

By Mr. David Rowan, President.

In beginning the business of this, the fourteenth session, I have much pleasure in being able to state in reference to all the objects for which this Institution was established, that it continues to prosper. The number of its membership and its financial resources continue to be most satisfactory, while the direct objects for which the Institution was established, namely, " The exchange of information amongst its members

to place on record the results of experience elicited in discnssion, and to promote the advancement of science and practice in engineering and shipbuilding." In the fulfilment of these objects it has becu eminently successful, as is illustrated by the large amount of valnable information contained in the papers which have been read at the meetings, in the free and full communications of practical experience elicited in the discussions and recorded in the transactions, and in the scientific deductions from this experience which indicates the direction for futnre research, and becomes the guide for for fnture practice. One of the most obvious results of our attending the stated meetings of such an Institution as this, and which I trust each member has experienced, is the growing regard and esteem which we entertain toward each other. Business may have its asperities and its engrossing personal interests, but here we meet on a common platform, with many objects of interest common to all. Out of this condition spring sentiments of friendship and pleasnre in each others society. It appears to me to be most respectful in these opening addresses, previous to the introdnction of any of the subjeets connected with the business of the Institntion, that we should record our sense of the loss which the Institution may have snstained by the decease of any of its members during the preceding twelvemonths. In accordance with a resolution of this Institution, I shall briefly take notice of the professional career of two important members of this Institntion who have been removed by death from amongst us, namely, Mr. Willian Tait and Mr. Neil Robson. I believe it to be the intention of Dr. Rankine to read an abridged memoir of Mr. Elder, lately President of this Institntion. Mr. Tait was born near Carluke, Lanarkshire, in January, 1810; when 15 years of age he became an apprentice with Messrs. Burton and Rowan, Engineers and Millwrights in Glasgow, on their giving up bnsiness he completed the remainder of his apprenticeship with Messrs. James Gray and Co., Washington Street. About 1836 he entered the service of Messrs. Mather, Dixon, and Co., Engineers, Liverpool, where his attention was first directed to the locomotive engine. Returning to Glasgow in 1839, he commenced the work of locomotive constrnction at the Atlas Works, Mr. John M. Rowan. In 1845 he was engaged as manager of the Hyde Park Engine Works, then Messrs. Mitchell and Neilson, and introduced the manufacture of locomotive engines into that establishment. From that date, this branch of engineering has attained a permanent place in our city; for although locomotive engines had been made in Glasgow years before this date, at the Hill Street Foundry, aud at St. Rollox Foundry, Mr. Tait was the first who organised this as a distinct department of engineering, with special arrangements and tools, and men trained in that particnlar department. The result is that we have now two of the best eqnipped locomotive works in this or any other conntry, and doing the highest style of work. Mr. Tait's more recent progress as a designer and maker of sngar plantation machinery, is better known to most of onr members. In this field of engineering, the firm of which he was a partner, were well-known for the excellence of their machinery. His personal qnalities, as well as his skill and energy of character, contribnted largely to the extension of this mannfacture in Glasgow. His death took place on the 30th April, 1868. By that event this Institution lost one of its most attached and usefnl members.

Mr. Neil Robson was born in the district of Galloway 1807. His father removing into Ayrshire, Mr. Robson was educated at the Irvine Academy, a school of no mean celebrity. At the age of seventeen he became an apprentice with the late Mr. Smith, Civil and Mining Engineer, in this city. On the expiry of his term of apprenticeship he began business on his own account, which he prosecuted with eminent success for the long period of thirty years.

In 1860 he assumed the management of the extensive works of Messrs. Merry and Cunningham, Coal and Iron Masters; shortly thereafter he was admitted a member of the firm. Amongst the principal works executed by him him may be mentioned the Glasgow, Barrhead, and Neilston Railway, with the great diagonal bridge near the South-side Park; the General Terminus Railway; the Caledonian and Dumbartonshire Railway; the Glasgow and Helensburgh and the Lesmahagow Railways; the Suspension Bridge over the Clyde at Glasgow Green is also one of Mr. Robson's constructions. He possessed an accurate and extensive knowledge of the geology of this dstrict of the country. He was a director of the Greenock and Ayrshire Railway, and for many years a director and the deputy governor of the Forth and Clyde Navigation Co.; he was a member of the institntion of Civil Engineers, London, and also of the North of England Institute of Mining Engineers; he was an honoured member of this Institution from its commencement until the time of his death, taking an interest in all its proceedings, and attending the meetings regularly, when his time permitted. His death took place after a short illness in February, 1869.

The joint meeting of the North of England Institute of Mining and Mechanical Engineers with this Institntion held on the 9th, 10th, 11th, and 12th Augnst, were eminently successfnl. The subjects treated of at those meetings were in great measure connected with the coal and iron interests, the importance of which can hardly be over-estimated, forming as they do, the basis on which in great measure depends the mechanical and manfacturing industries of this country. Although minerals are found under very different circumstances—some in layers or strata, as the ironstone of the coal measures and coal—others in veins or fissures, as copper, lead, and tin, the primary conditions for extracting those minerals although differing in detail, are similar in all, and consist of the sinking of pits, the pumping of water, the ventilation of the mines and raising the mineral. While these conditions are few in number, the contingencies of faults and dykes and mineral veins, which by the miners of this district are embraced in the general term "tronbles," with accidents in the mines arising from causes too numerons to mention, are sufficient to tax the skill of onr ablest mining engineers. Papers were read at those meetings, first "On the Geology of the Coal Measures of Scotland;" "On the Magnetic Ironstone of Rosedale Abbey, in England;" "On Pumping Engines;" "On Mechanical Ventilation;" "On Coal Getting Machines;" "On the Utilisation of Blast Furnace Gases;" and "On Mineral Oil Works." As the papers which were read at the meetings, with the discussions which followed, will very soon be in the possession of the members of this Institution, I cannot refer to them further at present. The success of the joint meetings was greatly promoted by the assistance which this Institntion received from the pnblic authorities in granting the entire use of the Corporation Galleries for the purposes of the meetings; from the personal kindness and the great interest taken in the success of the meetings by the Honourable the Lord Provost; by the Iron and Coal Masters, Engineers, and Shipbuilders of this district in contributing so liberally, that sufficient funds were available to meet without further effort, the expenses of the meetings; by the Lochlomond Steam Boat Co., and the North British Railway, as represented by Robert Young, Esq., of Balloch, in providing free of charge, the entire conveyance for the pleasure excursion to Lochlomond and back to Glasgow; to the proprietors of the public works in the city and surrounding district, in throwing open their works for inspection, and providing in the most liberal and sumptuous manner for the entertainment of the members; to Mr. James Thomson, Mr. John Young, Mr. Armstrong, Mr. Wunsch, Mr. Glen, and others, members of the Geological Society, for contribnting from their private collections, aud constituting one of the most complete exhibitions of fossils, principally from the carboniferous and mineral deposits of this district ever brought together in the same compass. Mr. James Thomson exhibited his most ingenious method of illustrating by the aid of the oxy-hydrogen light, the internal structure and configuration of coral and other fossils; to engineers and shipbuilders for exhibiting machines of various kinds, and models and specimens of naval architecture; and last, although not least, to the personal character and ability of the President of the North of England Institute, Mr. E. F. Boyd, in presiding over the joint-meetings. The conversazione and dinner were in keeping with the other arrangements. and were quite snccessfnl. At the conversazione, this Institution presented a marble bust of Dr. Rankine to himself, and were to have retained one. Owing to one of the busts being in London at the time, this arrangement could not be fully carried out; the bust now, however, adorns the hall of this Institution. I think it is only right to state here that the idea of this presentation was originated by the late Mr. John Elder, who, at a comparative early age, in the midst of a career of great success and nsefnlness, when President of this Iustitution, was arrested by death at the time when the artist was engaged in executing the work. I have much pleasure in stating that as soon as Mrs. Elder learned the interest which he had taken in this presentation. she at once expressed the desire to be allowed to carry out so far as in her power every wish of Mr. Elder in reference to one who stood so high in his estimation as Dr. Rankine; and it is as pleasing as it is jnst to state that Mrs. Elder, in the most generons way, and quite unsolicited, contributed largely to the presentation.

Of the papers read dnring the past session, that by Mr. Hird "On the Denburn Valley Railway" was a valuable contribution to those engaged in railway work. The author gives a brief historical account of the railway companies existing so far back as the year 1845, by whom this line of railway was first projected. Mr. Hird treats the subject of his paper under four general divisions; that at of earthwork and walling, tunnels, bridges, and the joint station. The author supplies drawing of the prineipal parts of the works, with figured dimensions, also the cost at which the principal parts of the undertaking was executed, thereby contributing most important information to those engaged in such work.

The paper by Mr John Price "On some Improvements in the Scantling of Iron Steam Vessels."—This paper does not pretend to bring forth anything novel in reference to the scantling of iron vessels, but is more correctly a comparison of the two well-known registries, that of the Lloyds and Liverpool rules. This paper was distinctly illnstrated by giving the scantling of 19 vessels of various tonnages ranging from 500 to 3,000 tons, according to the two registries. The comparison was

illustrated by distinct drawings, with figured dimensions of the seantlings of the two registries. Since the date of this paper, Lloyds have issued a revised set of rules. basing the proportions of their seantlings on an entirely new set of measurements, by whieh the two registries are brought more elosely into harmony with each other. It is greatly to be regretted that in sueh an important braneh of industry as shipbnilding, that two registries should exist, differing so little from eaeh other on any important particular; by either of the registries first-class merehant ships may be built; on many essential partieulars, that which is preferable is a mere matter of opinion. When vessels are built to class in both registries, the carrying out of both sets of rules in the same vessel, under the respeetive surveyors of both registries often beeomes a matter of the most vexatious difficulty to the practical shipbuilder.

Paper by Mr. W. Montgomerie Neilson "On a proposed Channel Ferry Steamer."—This snbject has been under the consideration of some of the more prominent shipbuilders of England. I may briefly state the difference of opinion that seems to prevail amongst those who have eonsidered this question. Mr. Neilson proposes a vessel 350ft. long, 75ft. beam, with a draft of water not exeeeding 5ft.; the main deek to be 2ft. above the water-line, the height between main and spar deck being 10ft. 6in.; a dipping keel 160ft. in length suspended by suitable arrangements—this keel to be made to deseend to a depth of 18ft. under the bottom of the vessel, to be raised by donkey-engines when approaehing the harbour and lowered when at sea; the vessel to be propelled by 4 paddle-wheels, eaeh having its own engine separate and independent from eaeh other—sueh vessels being intended for the conveyance of passengers only. The scheme nnder eonsideration by the English shipbuilders is that of a Channel Ferry Steamer, eonveying railway trains both goods and passenger. The evidence given before a eommittee of the House of Commons upon the International Communication Bill in May of this year by such men as Mr. E. J. Reed, Mr. John Penn, Mr. Samuda, Mr. Laird, and others, upon all the disputed points of the scheme was most important. Mr. Neilson's objeetions to the conveyanee of passengers in railway trains was the waut of harbour aecommodation and the faet that passengers were more comfortable in the saloon of a steamer than in a railway carriage. The argument in favour of earrying the trains is to save the transhipment of merehandise and luggage. The International Communieation Scheme embraees the construction of a breakwater at Dover enclosing a harbour of some 30 aeres in extent, and dredged to a depth of 16ft. On the French coast similar works are projeeted at a point nearly opposite to Dover. The vessels proposed for this traffie are 450ft. long, 57ft. broad, with a draft of 12ft. to 12½ft., propelled by engines of 1,600 horse-power nominal; it is proposed to earry by these steamers trains of merehandise below, and passenger trains above. Any objection as to the weight of the trains may be dismissed when the displacement, namely, 4,500 tons, is taken into aeeonnt, while the trains, goods and passengers, may be assumed as not exeeeding 150 tons eaeh, or 300 tons in all.

Before closing this subject, I may state that interesting papers were read at the meetings of the Institution of Naval Architeets in April of this year by Vice-Admiral Sir Edward Belcher and Mr. John Seott Russell. The papers, with the diseussions, are given in the transactions of that institution. I may state for those interested in the question that Admiral Belcher proposes a vessel of peculiar construetion and strongly recommends hydraulie propulsion.

A question of eonsiderable praetical importance was brought before the Institution by Mr. Clinkskill who exhibited several pieces of boiler plates cut out of boilers for supplying honses with hot water; the boilers were used with Loch Katrine water. The aetion on the plates was evidently due to a more aetive agent than ordinary eorrosion, the surfaee of the plates being irregularly honey-combed to [a considerable depth. In the case referred to, the eistern was of lead, the boiler and eonnecting pipes of iron, thereby forming a galvanic battery, sufficient to account for the destruction of the plates. From the experionce obtained, it appears advisable that in the construction of snch hot water apparatus, the cistern, the boiler, and the connectibg pipes should all be of iron, or, at least, of one kind of material.

Of all the papers read during the session, that by Mr. Robertson on the the Patent Laws occasioned the most prolonged discussion. This paper is an argument in favour of the idea that every inventor who constructs a new machine or process of manufaeture is entitled to consider such invention as his own property, and the right to make, use, or sell, or allowing others to make, use, or sell, what he has invented, shall rest entirely and exelusively with himself. Mr. Hunt and Mr. Newall assume theso conditions as granted, and propose eertain modifications and changes in the Patent Law as at present existing. These may be briefly stated, as follows:—Mr. Hunt proposes that the cost of a patent shall not exceed that which is neeessary to cover the expenses of the Patent Office: if Government decide that patents shall contribute to tho revenue of the country, let that be by a tax on tho incomo derived from the patent. He proposes to adopt, with eertain modifications, the patent system of the United States—especially the plan of examining into the novelty of inventions proposed to be patented. An important feature in the American system is that an inventor can get a patent so long as his invention has not been in use more than two years. In this country a patent is invalidated by previous publieation. Mr. Newall proposes as follows:—The appointment of a standing commission, who shall examine in pnblie all petitions and speeifications before granting a patent. When a patent is granted it shall be held as valid, if not assailed within two years under eertain eonditions. The eommission to be selected by the Privy Council from amongst those who are intimately aequainted with the arts and seienees. The term of a patent to be for 20 years. The cost payable in four equal sums of £50 eaeh. To grant patents for inventions whether by Foreign or British subjects. Mr. Hunt and Mr. Newall both propose the infliction of imprisonment for infringement. Althongh much time was devoted to this subjeet without arriving at any decision, a eareful perusal of Mr. Robertson's paper, with the snggestions by Mr. Hunt and Mr. Newall, will show that the time was not misspent. These papers contain the clear and well defined opinions of men of large experienee, who have devoted much attention to a subject on whieh many amongst us were but partially informed.

The history of engineering praetiee illnstrates, that while mechanical applianees have been adapted to supply the wants of man, wherever sueh ean be used to advantage, progress towards a more perfect eondition eannot be said to have been uniform, but rather to have had periodic times of ehange. That of the steam engine itself may be said at times to have retrograded. The steam jaeket of Watt had been departed from in great measure for many years in the praetiee of engineering. The donble eylinder of Woolf may be said to have shared the same fate. While the surface condenser of Hall was completely discarded for several years. The donble cylinder engine came into favour in factory operations by Mr. M'Naught applying a high pressure eylinder to beam engines, allowing the steam to expand in the eondensing eylinder. Within the past fifteen years, the surface condenser has come to be generally used in marine engines. The researehes of Dr. Rankine in showing the correct use and advantage of the steam jacket has again brought it into eommon practice. The natural result of the steam jaeket and surfaee eondenser—the one enabling a large measure of expansion to be used with advantage—the other a high pressure of steam to be maintained with safety at sea, has been the donble cylinder engine, whieh may be said to be the only engine now made for marine purposes. Marine engineering has now arrived at a stage when present praetice may, with slight modifieations, be expeeted to continne for some time. By the more eorreet knowledge of the principles on which economy in the use of steam depends, we may be expected to have passed that transition period when each new pair of engines was thonght to eonsume less fuel per horse-power than its predeeessor.

Marine Boilers.—It has been found difficult to eombine the best form for the applioation of heat, with the meehanical structnre for strength of form withont the use of stays, uniform expansion of the several parts, provision for the proper eireulation of the water, with space for steam without priming. The attention of engineers will continue to be direeted towards an improved form of boiler.

Locomotive Engineering.—Sinee the introdnction of Giffard's injeetor, the slide valve relieved from pressure on the baek, the application of means to prevent smoke and ashes deseending into the eylinder when running down hill, with slight modifieations to suit the taste of superintendents, and the several purposes to whieh it is to be applied, as goods or passenger traffie, the locomotive engines of the present day resemble eaeh other in almost all particulars.

Surface Condensers.—At the exhibition in connection with the joint meetings of the North of England Institnte, Mr. Henderson of Leith exhibited a snrface condenser differing from the eommon tubular form. It consists of a donble casing of eopper through which tho eondensing water flows, and enclosing a large enbical space into which the steam is passed for eondensation. The surfaco exposed in this eondeuser is small when eompared with that of the tnbular form. Condensation seems to take plaee not so much on the metallie surface of this condenser, as by the steam being passed into a large chamber surrounded with cold water.

The removal of the sewage of the city, and the purification of the water of the Clyde, is a subject to which for several years mnch attention has been devoted. Many sehemes havo been proposed of a chemical eharacter and others, and mneh discussion has followed thereon. Perhaps the only reliable plan yet proposed of effecting the objeet in view is, the mechanical method of pnmping and irrigation detailed by Messrs. Bateman and Bazalgette.

Several pnblie works of great importauce are being carried out in this city at the present time, which I shall only mention as we may have papers relating to some of them during the session. The New Bridge

on the site of the old Hutchesontown Bridge, carried out by two of the members of this Institution, Messrs. Bell and Miller, is the first Iron Bridge for common road traffic crossing the Clyde. It is founded on cast-iron cylinders sunk to a great depth until they rest on the solid rock, and when completed will have an appearance of elegance in design —a beauty in its proportions—conveying the impression of great strength along with that of lightness of structure, not surpassed, I believe, on these points, by any bridge in the kingdom. The New Graving Dock near Govan is being pushed forward with great vigour. The Union Railway has not yet been opened for public traffic, but is expected soon to be so. The new railway terminating at Galbraith-street, West-end, and running along the projected Stobcross Docks, forming a junction with the Helensburgh Railway near Maryhill, is about to be commenced; the engineering of the line will also be entrusted to two members of this Institution, Messrs. Forman and M'Call.

Our harbour is being continued downwards, opposite Stobcross. The method adopted for the quay wall of this harbour extension is, I believe, entirely novel as applied to harbour works. In the present instance, the old method of wood piles or stone walls has been departed from, and cylinders of brickwork resting on an iron shoe or sole plate dovetailed, or rather, feathered and grooved into each other, and sunk to a depth sufficient to give a permanently solid foundation will form the line of the quay wall. These cylinders may be filled with concrete if thought necessary. The same apparatus for excavating under water, and for sinking cylinders, is being used in this case as in that of the iron cylinders of the Union Railway Bridge crossing the Clyde. From a paper read at the Institution of Civil Engineers by Mr. Imrie Bell and Mr. John Milroy, it appears that the plan of sinking wells built of masonry or brickwork for the foundations of walls on the banks of rivers where the soil is sandy has been in use for may centuries in the East Indies. The large railway bridge on the Delhi Railway, crossing the river Jumna, rests on such foundations.

Compass Correction.—Arrangement have been made for a course of lectures during this Session by the Professor of Astronomy on Compass Deviations. A short course of four lectures was delivered during the summer by the Assistant Professor of Mathematics: during that season of the year almost all seafaring men are on voyages; and the lectures were consequently not well attended. This may also have arisen from the want of a proper appreciation of the importance of the subject to those having charge of ships at sea. It is well known that the deviation of the compass in iron ships, due to the magnetism of the ship's iron, is attempted to be neutralised by the introduction of permanent magnets. This operation is performed when the vessel is on even keel; were this position always maintained at sea, all would be well (excepting from causes of change in different latitudes). It is quite apparent when a ship is heeling over with a beam wind, the whole relationship of the adjusting magnets and the magnetism due to the ship's iron, in reference to the compass, becomes deranged, and when on the reverse tack the evil is doubled; and the compass on which the safety of all depends becomes an incorrect guide. With the extraordinary development of iron ship building during the past quarter of a century, followed by the loss of so many sailing and steam ships, and the fearful sacrifice of human life generally accompanying such loss; surely when a cause is known to exist, which may not only lead astray, but lure to destruction, it ought to be imperative that those on whose skill so much depends, should be well informed as to the causes producing these deviations, and as far as possible how to correct them. There is no doubt that more of those fatal disasters are due to this cause than is supposed. One of the duties this Institution has imposed on itself is to direct public attention to this fertile source of loss, and so far as in its power to supply the education necessary for its prevention.

The Incorporation of this Institution by charter only awaits your decision in reference to certain slight modifications in the Articles of Association proposed by the Board of Trade. By this step, this Institution will be raised in position and take rank with such Incorporate bodies as the Faculty of Physicians and Surgeons, the Faculty of Procurators, &c., only they will be our seniors in point of age: up to the present time, all the Institution's engagements have been made on the responsibility of the Council; it could neither hold nor lease property; it could neither sue nor be sued for debt; it was not recognizable by law, except as represented by the members of Council.

In drawing these remarks to a conclusion, I observe with pleasure that this Institution contains all the elements of great prosperity, and that an important future is before us. We have amongst our honorary and ordinary members the most advanced and distinguished names in physical science in civil and mining engineering, in shipbuilding, in marine locomotive, and land engineering in all departments. Members of this Institution occupy the foremost places. It may not be too much to express the hope that as this Institution extends in influence and importance in promoting the advancement of science and practice in engineering and shipbuilding, that it will in the future extend its influence towards the graduates and younger members in promoting that technical education which other nations, our competitors in business, boast of, but which many of the young men in our city, members of these professions, have not, up to the present time, had an opportunity of acquiring.

INSTITUTION OF CIVIL ENGINEERS.

ON THE THEORY AND DETAILS OF CONSTRUCTION OF METAL AND TIMBER ARCHES.

By M. JULES GAUDARD, of Lausanne.

(Translated from the French by Mr. WILIAM POLE, F.R.S., M. Inst. C.E.)

Elastic arches supporting a road or railway were connected to the horizontal platform by pillars and filling pieces, occupying the spandrels. The office of these parts was to transmit the load of the platform to the resisting arch; no other function was usually attributed to them, and the arch was the important member on which the whole rested. The spandrel, however, forming always a rigid filling or system, contributed powerfully to increase the resistance of the structures, so that it would be justifiable to consider as the chief member, not the isolated arch, but the framework, more or less complex, constituted by the arch, the spandrel filling, and the longitudinal horizontal piece placed at the level of the platform. Under this point of view, the arch might be assimilated to a chain of articulated segments, presenting two modes of calculation which were severally examined. In the articulated system it was necessary to choose a single triangulation, where every piece was essential; for otherwise, if, for example, two diagonals were introduced in each bay, the calculation would become indeterminate. At the summit, the two half-spans were joined by a simple point of articulation, like those of the other summits of the triangulation, while the longitudinal horizontal piece was useless in theory; and in practice it would be desirable to provide it with a free sliding joint, in order that nothing might impede the expansion of the fixed portion. Under these conditions, the elements of statics furnished easily the stresses on all the pieces, of which an example was given. When the stresses in the various parts of the arch or of the longitudinal were known, the stresses in the spandrel bars could be deduced by simple graphic decompositions, based on the equilibrium of the summits of the system. Of this also an example was given, with further calculations. For a determined fixed load there might be given to the arch the form of a funicular polygon, a figure of equilibrium such that the articulated chain might maintain itself in position without the intervention of the other pieces of the framework. In a bridge the load varied, but it was desirable the figure of the arch should approach that of equilibrium corresponding to the complete load. This form would be the curve called the catenary for an arch of uniform section carrying only its own weight, and the parabola for an arch loaded uniformly per unit of length on a horizontal line. This latter was the case in suspension bridges, and also in bridges with compressed metallic arches, for the weight of the arch and the spandrels had but little influence, proportionately to that of the horizontal platform and its test load.

The second mode of calculation referred to rigid arches, and consisted in restricting the spandrels to simple supports for transmitting the loads. The arch was then more strained, and ought to be rigid, for the funicular form only gave an instable equilibrium, corresponding to a particular state of the load. As soon as this state was changed, the arch no longer suffered simple compression, but was disposed to bend, *i.e.*, to change its figure. In an arch of masonry, the effect of the mortar was neglected, and the voussoirs were regarded as blocks placed in juxtaposition without adherence, having the power of pivoting one on the other, round the edge either of the intrados or of the extrados; that was what was called a system of alternative articulation. The centre of pressures, *i.e.*, the point of application of the resultant of the elementary reactions of the joint, was considered for each joint. The locus of these centres, or the curve of pressures, ought not to pass outside the thickness of the arch, or the pivoting of certain of the voussoirs would take place; the curve ought even to keep within a zone more limited than that of the arch, for fear of endangering the crushing of the stones. An elastic arch was subject to other conditions. If the connection was very good, as was (or ought to be) the case with plate iron, the arch formed an entire piece, suitable to resist both tension and compression. If it was treated as an arch by the curve of pressures, this curve would no longer be required to remain within the arch. When the arch rested upon the abutments by an extending sustaining surface, being keyed by a range of wedges, there was nothing to prevent certain of these wedges being driven tighter than others. This would then modify the point of concentration

of the thrust upon the abutment, and consequently also all the other points of the curve of pressures. Hence arose the uncertainty which generally attended the method of the curve of pressures, these pressures only being determined by arbitrary data in regard to the original keying-up, or the yielding of the materials. The author considered the proposal to provide a metallic arch with three pivots, or hinges, one at the summit, the other two at the supports; but hitherto, so far as he was aware, no one had ventured to apply three pivots to large works. M. Mantion had, however, employed two pivots at the supports in an iron bridge of the St. Denis canal, and the effect of such a system was examined. The theoretical calculations of deformation might be applied with confidence, where the arches consisted of a single piece of homogeneous metal. Arches in solid wrought-iron plate might be considered to belong to this category, the metal having been well worked, and the connections being as solid as the continuous parts. The theory of these arches had been the object of the researches of M. Bélanger, and subsequently of M. Bresse, who had entered into great detail respecting them in his treatise on Applied Mechanics (Stabilité des Constructions). An explanation of his principal formulæ was then given. The author next proceeded to consider the details of construction of arches of different materials. He remarked that, structures in timber were the most economical in many countries, but their durability was limited. The principal type of timber arches appeared to be that inaugurated at Yvry (Seine) by M. Emery, where the arches were composed of strong pieces of carpentry superposed to the number of three, for example. But it was preferred in many cases to leave open the intervals between the several pieces, in order to allow better ventilation, and to prevent them from heating; and further, because this plan gave an increase of depth to the arch, and consequently a more ample field to the oscillations of the curve of pressures. Certain timber bridges presented a compressed arch, a tensile tie-bar, and vertical connecting-rods, a system which was allied to the bowstring form. The flat arches of Wiebeking (Bavaria), and those in thin layers of planks superposed of Emy, would appear only suitable for roofing purposes, being too subject to deformation for bridges. Among the American forms of trellis framework for straight beams, capable of competing with arched openings, the system of Howe, having iron vertical tie-rods, deserved special mention. Cast iron resisted compression well, but tension badly. It made good arches in the cases where the curve of pressures did not pass out of a certain central zone, and where the flexure was nothing, or insensible; and on the condition that there were no powerful vibrations, *i.e.*, that the dead weight was large compared to the moving load. This last consideration led, in the case of railways, to the spreading of a thick layer of ballast on the platform. in spite of the increase of load resulting therefrom. Wrought iron was preferable to cast iron, notwithstanding its higher price, whenever there was reason to fear the effects of flexure in certain parts, or when it was desired to make a light structure, without loading of ballast. There was also an opportunity of adopting pivoted supports, and of calculating the thrust according to the theoretical deformation. However, this conclusion was not absolutely true for trellised arches, which it was necessary to use in the case of very larger spans. Such, for example, was the bridge at Coblenz over the Rhine, consisting of three arches, each 317ft. span. In general, a solid plate web was preferable to trelliswork for arches of moderate dimensions. In effect, the flexure was small, and the longitudinal pressure much predominated; the solid plate acted, consequently, more usefully than in a straight beam, which presented neutral fibres. Moreover, it would only be necessary to employ rivets at considerable intervals in the parts outside the joints. To satisfy the most advantageous condition, viz., a large moment of inertia, without too great depth, it was desirable to adopt for the section a double T with large wings. For large openings, however, a box section appeared to be preferred. The lateral stiffness would depend essentially on the cross framing which connected together the different arch ribs of the same span. Where this resource was wanting, *i.e.*, where an isolated arch rib must maintain itself alone, the oval section, analogous to that of the arches of the bridge at Saltash, presented itself as one of the most favourable. Wrought and cast-iron might be associated in the same work. This combination had been adopted in a bridge of three arches constructed in the park at Neuilly, near Paris, many details of which had been suggested by the new Westminster Bridge. All the pieces essentially under compression, *i.e.*, the spandrels and the portions of the arch near the abutments, had, for the sake of economy, been made of cast-iron, while the central portion of the arches and the longitudinal bearers of the platform were of plate iron. Arched bridges were, on principle, often more economical than those formed with girders; they admitted better of an augmentation of the dead weight, for the purpose of deadening the vibrations and increasing the probable durability. But it was necessary that sufficient height should be available, and that the abutments should be able to resist the thrust. When the work was low and the ground solid, it was easy to give the abutments the necessary stability, without too much expense. The compression, tending to close the molecules of the metal, appeared to promise to such works a longer duration than would be due to pieces in tension, which threatened, after a long period, to be subject to enervation. These considerations in favour of arched bridges were, it was true, somewhat counterbalanced by the greater complication of the forms. Bow and string bridges were, as the words implied, arches provided with a tie-rod which received the thrust upon the extremities, without the intervention of supports: so that the abutments were freed from the effect of these thrusts, and only exerted reactions in a vertical direction. The most remarkable example was the bridge at Saltash, of two great spans of 456ft. each. The arch, being single, had to be kept at the two ends at the height above the roadways necessary to leave a free passage for the trains; and this led the eminent designer, Mr. Brunel, to adopt a curved tie, and to suspend the platform at a lower level. When there were two arches, one on each side of the road, there was nothing to prevent their extremities descending to the level of the platform; the tie was then straight, and being strengthened in order to serve as a longitudinal bearer, it might support the roadway. An example of this disposition was the bridge of Audenarde, on the Scheldt.

In conclusion, the author referred to a work he had published in 1865, ('Etude comparative sur les Ponts en Fer') in which he had given formulæ expressing the stresses on the various parts of bow and string girders, as well as the comparison between this and other systems of construction.

At the meeting of this Society on Tuesday the 6th ult., Mr. Charles B. Vignoles, F.R.S., President, in the chair, the first ballot for the present session was taken, when thirty-seven Candidates were balloted for and declared to be duly elected, including eleven members, viz.: Mr. Crawford James Campbell, Superintending Engineer, P.W.D. Indore; Mr. John James Carey, Ex. Eng., P.W.D., India; Mr. William Bellingham Carter, District Engineer, East Indian Railway; Mr. Walton White Evans, New Rochelle, U.S.A.; Mr. Alexander Fraser, Resident Engineer to the Grand Junction Water Works Company; Mr. William Frederick March Phillipps, District Engineer, Punjâb Railway; Mr. John Arthur Phillips, Aigburth, Liverpool; Mr. Arthur Potts, Chester; Mr. Joseph Quick, jun., Sumner Street; Mr. William Robert Robinson, Resident Engineer, Madras Railway; and Mr. Edward Welsh, Engineer to the River Witham Commissioners. Twenty-six gentlemen were elected Associates, viz.: Mr. Charles Angustus Alberga, Stud. Inst. C.E., Buckingham Street; Mr. John Philip Cortlandt Anderson. Ex. Eng. P.W.D., India; Mr. Thomas Ashton, late Superintending Officer P.W.D., Ceylon; Mr. Robert William Peregrine Birch, Stud. Inst. C.E., Westminster; Mr. James Bisset, Cape Town; Mr. Joseph Bourne, Resident Engineer, &c., of the Isle of Wight Railway, Saudown; Mr. John Charles Coode, Stud. Inst. C.E., Westminster; Mr. Charles Cowan, Valparaiso; Captain Arthur Edward Downing, Assistant Surveyor, Topographical Survey of India; Mr. Frederick Dresser, Assistant Engineer, Bombay P.W.D.; Mr. Francis Fox, Westminster; Mr. Thomas Wilson Grindle, Borough Engineer, Hertford; Mr. John Falshaw Hobson, Assistant Engineer, Great Indian Peninsula Railway, Bombay; Mr. Arthur Lucas, Westminster; Mr. James Chatburn Madeley, Resident Engineer of the Honduras Interoceanic Railway; Mr. William Matthews, Westminster; Mr. George Palmer, Assistant Engineer, P.W.D., Government of H.H the Nizam; Mr. Alexander Rhodes, Assistant Engineer, Great Southern of India Railway; Mr. William George Scott, Assistant to Resident Engineer, Manchester, Sheffield, and Lincolnshire Railway Company; Mr. Peter Soames, Southampton Street; Mr. Herbert Unwin, Engineer to the Gas Works, Sheffield; Mr. Thomas Finsbury Septimus Wakley, Assistant Engineer, East Indian Railway; Mr. William Thomas Walker, Donnington, near Newport, Salop; Mr. Edward Orange Wildman Whitehouse, Hampstead; Mr. Charles Henry Willes, Ex. Eng., Madras Irrigation and Canal Company; Mr. John Hatton Wilson, Ex. Eng., P.W.D.; India. It was also announced that, acting under the provisions of Section IV. of the Bye Laws, the Council had recently admitted the following Candidates as Students of the Institution: Arthur Turnour Atchison, James Thomas Atchison, Edward Kynaston Burstal, Edmund Emson, Walter Freeth, Charles John Goodman, Arthur Grose, Arden Hardwicke, Fletcher James Ievers, Frederick Jackson, Walter Robert Jones, John Herman Merivale, John Nowlan, William Patterson Orchard, Ernest Edward Sawyer, Gilbert Stiff, Thomas Sugden, Joseph Calisto Grosvenor du Vallon, and Charles Edward Sabino Younghusband.

THE FIFTY-THIRD ANNUAL GENERAL MEETING.

T. Hawksley, Esq., Vice-President, in the chair.

The report of the council stated that, during the past session, there were twenty-five ordinary meetings, at which fifteen different subjects were discussed, These related to the theory of the Resistance of

Materials, the Strength of Iron and Steel, the Public Works of the Province of Canterbury, (New Zealand), the Saó Paulo railway, (Brazil), the Mhow-ke-Mullee viadnct on the Great Indian Peninsula railway, the Pennair bridge on the Madras railway, the St. Pancras station and roof of the Midland railway, the statistics of Railway Income and Expenditure, the maintenance and renewal of Railway Rolling Stock, the Low Water Basin at the Birkenhead docks, the Wolf Rock lighthonse, Ocean Steam Navigation, tho proportions of Rotary Fans, the Dressing of Lead Ores, the relative safety of different modes of Working Coal, on Coal Mining in deep workings, and on improvements in Regenerative Hot-blast Stoves for blast furnaces.

For some of these communications premiums had been adjndged, which were presented after the reading of the report, inclnding Telford medals and Telford premiums of books to Messrs. E. Dobson, T. Sopwith, jun., and J. N. Douglass; Watt medals and Telford premiums of books to Messrs. R. Price Williams, J. T. Harrison, G. Berkley, R. Briggs, and E. A. Cowper; Telford premiums of books to Messrs. J. Grantham and D. M. Fox; and the Manby premium of books to Mr. E. Bainbridge. In accordance with custom, the paper descriptive of the St. Pancras station and roof, by Mr. W. H. Barlow, did not come under consideration in the adjndication of the premiums, the Author being a member of council. The warm thanks of the Institution were, however, justly dne to Mr. Barlow for his valuable contribution.

The "Minntes of Proceedings" for the past session, which were issned during the recess at an earlier date than usnal, exceeded in amount of matter and in the number of illustrations, the publications of any previous year. For the sake of convenience these proceedings had been published in two volumes, each of 500 pages, and containing together 37 plates, instead of in one volume of 650 pages, with 26 plates, as in the previous year. Besides the articles already referred to, Mr. Callcott Reilly had furnished a memoir explanatory of the principles on which two iron girder bridges, recently execnted, had been designed, with the calculations on which the dimensions of the several parts had been determined. This memior the council had great pleasure in accepting for publication, and had expressed to Mr. Reilly their appreciation of his labours.

In addition to the ordinary meetings. there were seven supplemental meetings, for the reading and discussion of papers by students; and for these communications Miller prizes had been awarded to Messrs. R. W. P. Birch, H. T. Munday, W. W. Williams, jun., S. Preston, E. Bazalgette, J. Harding, and the Hon. P. J. Stanhope. The conncil recorded their thanks to Mr. Fowler, Past President, Messrs. John Bazley White and Brothers, and Colonel Clarke, R.E., Associate of conncil, for facilities afforded to the students for visiting works in progress and manufactories; and the hope was expressed that similar privileges wonld be frequently extended to the students.

One of the duties devolving on the council under the Bye-laws was to arrange for the pnblication of such documents as might be calculated to advance professional knowledge. As an aid to this end, allusion was made to the volnme, lately issned, on "The Education and Status of Civil Engineers, in the United Kingdom and in Foreign Countries." This had been compiled from original reports and statements, by Engineers of eminence and by the anthorities of educational establishments, supplied to the council in reply to their inquiry for particulars as to the systems of instruction pursued in the training of Engineers.

The library continued to receive considerable accessions, by presentation, by exchanges with other societies, and by the purchase of all books which it was thought might prove nseful. The additions had been so nnmerons during the last four years as to necessitate the printing of a Supplement to the second edition of the catalogue. The collection now comprised about seven thousand volumes and four thousand five hundred pamphlets.

During the past session there had been a net effective increase of 44 members, 70 associates, and 35 students. There were on thc books, on the 30th of November last, 16 honorary members, 699 members, 988 associates, and 173 Students, together amounting to 1,876, as against 930 ten years ago.

The deceases announced since the last Annnal meeting had been nearly 22 per thousand, and comprised Peter Ashcroft, James Melville Balfour, John Braithwaite, Zerah Colburn, Frederik Willem Conrad, Samnel Dobson, Charles Caulfeild Fishe, John Harris, John Bernard Hartley, George Leather, Robert Morrison, George Paddison, Thomas Paterson, William Alexander Provis, Charles Sanderson, James Thomson, and William Weaver, Members; Henry Corles Bingham, William Thomas Blacklock, Robert Dunkin, Alister Fraser, William Gammon, General Sir William Gordon, Henry Hakewill, Conrad Abben Hanson, John William Heinke, George Houghton, Major Julian St. John Hovenden, Robert William Keunard, John Mceson Parsons, Joseph Pitts, George Selby, Gerrit Simons, George Henry Smith, Sir John Thwaites, George Barnard Townsend, and Captain James Vetch, Associates.

The nominal or par values of the funds under the charge of the Institution were: I. General Funds, £10,656 1s. 8d.; II. Trust Funds, £12,119 15s. 8d.; and III. Cash balance, £369 17s. 5d., together amounting to £23,145 14s. 9d., against £19,775 17s. 4d. at the date of the last report. Of these funds a sum of £10,163 17s. 4d. was invested in Government stocks, and the remainder. for the most part, in four per cent. Debenture Stocks of some of the leading railway oompanies.

The abstract of the receipts and payments for the past year, as certified by the anditors, showed that on the 1st of December, 1869, there was a balance in the hands of the treasurer of £268 9s. 9d., and there had been received sinoe (including the Appold bequests of £1,800), £9,653 10s., making together £9,921 19s. 9d. The disbursements had amounted to £6,583 6s. 10d., while £2,968 15s. 6d. had been invested, leaving a balance of £369 17s. 5d. Although a larger sum than nsnal had been expended in publications, yet out of the ordinary revenne £1,168 15s. 6d. had been invested, and the present cash balance exceeded the former one by £101 7s. 8d.

The following gentlemen were elected to fill the several offices in the council for the ensuing year:—Charles Blacker Vignoles, President; Thomas Hawksley, Joseph Cubitt, Thomas Elliot Harrison, and George Willonghby Hemans, Vice-Presidents; John Murray, George Robert Stephenson, Nathaniel Beardmore, William Henry Barlow, James Abernethy, John Frederic Bateman, James Brunlees, Joseph William Bazalgette, Frederick Joseph Bramwell, and Edward Woods, Members; and James Joseph Allport and Major William Palliser, C.B., Associates.

The thanks of the meeting were unanimously accorded to the president for his zealous efforts in the interests of the Institution; to the vice-presidents and the other members and associates of council for their co-operation with the president, and their constant attendance at the meetings; to Mr. Barlow for his paper on the St. Pancras station and roof; to Mr. Callcott Reilly for his memoir on iron girder bridges; to Mr. Charles Manby, honorary secretary, and to Mr. James Forrest secretary, for the manner in which they had performed the dnties of their offices; as also to the auditors of the accounts, and to the scrutineers of the ballot, for their services.

The meeting was then adjourned until the 10th, inst., when it was announced that the monthly ballot for members wonld take place, and the following paper wonld be read, "An Account of Floating Docks, and more especially of those at Carthagena and Ferrol," by Mr. George Banks Rennie, M. Inst. C.E.

ROYAL GEOGRAPHICAL SOCIETY.

ON THE GEOGRAPHY OF THE SEA-BED.

By Capt. Sherard Osborn, R.N.

The author gave an account of onr present knowledge of the configuration of the bed of the ocean, as derived from Admiralty surveys and Submarine Telegraph expeditions during the last fifteen years. His explanations were illustrated by a number of excellent diagrams, showing transverse seotions of the North Atlantic and of the Indian Ocean, and longitudinal sections of the North and South Atlantic and of the Mediterranean. The first general feature pointed ont was the absence from the sea-bed of those great and abrnpt ineqnalities which distinguish the surface of the land, and the softer undulations and greater levelness were attributed by the author chiefly to the planing action of currents. So level is the bottom of the Indian Ocean, that Captain Halpin, in laying the Indian cable, stated that for hundreds of miles there was no variation in the dynanometer of the cable's descent, and that it could have been laid at the fnll speed of the *Great Eastern*. Another important general fact that had resnlted was the proof of the error of all former statements of the very great depth of the ocean. No depth had been found greater than 2,900 fathoms (17,400ft.) It was true the Pacific had not yet been investigated; but a number of soundings had been taken in the North Pacific, and they showed a maximnm depth of less than 3,000 fathoms. The author entered into details regarding the valleys of enormous breadth and length that had been established as existing in the Atlantic and Mcditerranean, and also described the submarine plateans and the temperatures at different depths. He concluded by expressing the thanks of scientific men and others to Admiral Richards, Hydrographer to the Admiralty, nnder whom the great recent progress in deep-sea soundings had been carried out.

Professor Huxley expressed his dissent from the author of the paper, with regard to the great difference alleged to exist in the surfaccs of the

sea-bed and of the land; a difference which, he contended, would not appear if both were drawn on a true scale. This, however, only applied to the great general features of the surface; it took no account of the minor irregularities, which, on the land, were caused by the corroding action of rain and rivers. A recent discovery had shown that the most characteristic organisms of the deep-sea bed, named coccoliths and coccospheres, existed at all depths, even in shallow shore-waters, and were also found fossil in sedimentary rocks of all epochs;—a discovery of great interest, as confirming the view of the uniform conditions of submarine deposit in all ages of the earth's history. He was opposed to the view that the animals found living in the dark regions of the lowest sea-depths depended for light on the phosphorescence of some of the species, and saw no reason for concluding that they could not exist without light. He also doubted the accuracy of the very low temperatures found at great depths, and thought that those taken in the Indian Ocean might be explained by the fact that they were taken with thermometers not rectified for pressure. He concluded by giving warm praise to the British Government for the great work they had encouraged in these deep-sea surveys, and maintained that they had been unjustly assailed for their refusal to aid in furthering science, which they were ready to do whenever a good case was made out for their giving assistance.

Mr. Gwyn Jeffreys was convinced, from the soundings he had himself taken, that there were great inequalities in the bed of the North Atlantic. In one case, the same dredging gave depths of 1,055 and of 740 fathoms. In the same sea, gravel was very widely spread over the bottom, and there were often extremely rough flints, which, he thought, would be dangerous to submarine cables. Many of the animals he had dredged up from great depths were amply provided with organs of sight, showing that light was there existent. The submarine cable of the Mediterranean was subject to the attacks of boring animals—a mollusk and a crustacean.

Captain Sherord Osborn concluded the discussion by adducing, as further proof of the levelness of the deep-sea bed, the fact that the grapnels used to recover the severed cable of 1865 (only two inches in thickness) swept across the bottom for more than 100 miles; and in crossing the cable, scarcely ever failed to hook it, which could not have happened had there been abrupt inequalities of surface.

The following new Fellows were elected on the second Meeting of the Session held on Tuesday, November 29th:—Barkly, Sir Henry, K.C.B. (Governor of the Cape); Beer, Julius; Clapton, Edward, M.D.; Fairland, Edwin (Surgeon 21st Hussars); Grant, Andrew; Gottlieb, F.H., J.P.; Hooper, G.N.; Hitchins, Lieut. T.M, R.A.; Harbord, John B. (Chaplain R.N.); Hooper, Rev. R. P.; Harcourt, Capt. A. F. P.; Jessop, Capt. Thomas; King, Henry S.; Lyall, George (Deputy-Governor of the Bank of England); Latham, George, C.E.; Lindsay, Lord; Levert, A. L.; Mariani, L.; MacLeod, Lieut. A., R.N.; Macturk, John; Martin, W. C.; Nicoll, H. John; Nash, Samuel; Nichols, James; Pycroft, Sir Thomas, K.C.S.I.; Poole, C. M.: Parfitt, W. S., C.E.; Robinson, Hon. W.C.F. (Governor of Prince Edward's Island); Rice, William; Roos, G.E.A.; Ratcliffe, Rev. Thomas; Stanley, Henry (Lieut. R.N.); Sanford, W. A.; Turner, Major- General H. B.; Trutch, J. W. (Chief Commissioner of Lands and Works, British Columbia); Wilder, Frederick; Wodehouse, Sir Philip, K.C.B.

LAUNCH OF H.M. YACHT "OSBORNE."

Her Majesty's yacht *Osborne* was launched on the 19th ult. at Pembroke yard. The ceremony of christening was performed by the Countess of Cawdor. The *Osborne* was designed by Mr. E. J. Reed, C.B., ex-Chief Constructor of the Navy. She is a paddle steamer, with engines of 450-horse power nominal, supplied by Messrs. Maudslay Sons and Field, built with wood frame, and two thicknesses of diagonal planking, with fore-and-aft plank on the outside. She is 250ft. between perpendiculars, with a burthen of 1,542 tons, O.B.M. The details and fitments of this vessel are complete, and speak highly for the professional skill of Mr. R. P. Saunders, master shipwright, whose ideas have been carried out by Mr. T. G. Seccombe, foreman in charge of the ship. The arrangements for steering are quite noval, and have been cleverly adapted so as to add to the ornamentation of the yacht, as when navigating rivers and steering from the bridge the power from the wheel is applied to a vertical shaft, on which is fitted a sprocket-wheel working a pitch chain, which passes in a water-tight channel way, in lieu of a strake of planking on upper deck on each side of the ship; fitted with lignum vitæ rubbing chocks at intervals, so as to reduce the noise to a minimum. The power is thus conveyed to a Rapson's slide, thereby avoiding the liability of slack, and the stretching of ropes, the Rapson's slide working on a tiller fitted to the Norman head, a portion of which is ingeniously housed under the banquet stool. When at sea the steering will be managed from the banquet stool by Skinner's patent apparatus, working directly to the Norman head, and fitted, so as to work together with, or independent of, the foregoing system. In the event of the failure of the two systems mentioned, and the rudder head also disabled, arrangements are made to fit a spare tiller at the back of the rudder above water, to be used with pendants led inboard. The cabin ventilation is in every particular quite distinct from the general ventilating arrangements of the vessel, thus entirely preventing the distribution of the noxious gases generated in the bilges.

THE SMITHFIELD CLUB SHOW.

It is often remarked that when a person has once visited this show he can imagine the rest without troubling himself to attend another. As far as general appearance goes, there is, no doubt, some truth in the remark, but to any one who is interested in marking the progress of engineering, there are always a sufficient number of novelties to repay him for a careful examination of the various improvements or modifications invariably to be discovered by a little closer scrutiny. As it is almost impossible in such an enormous variety of machinery to attempt anything like a classification, we will simply begin with the first object that attracted us; which was a beautifully finished 10-h.p. fixed horizontal engine by Messrs. Clayton and Shuttleworth. The general arrangement is similar to their well-known pattern, but it is fitted with an independent expansion eccentric working a link, the block in which is attached to the governor, the action of which, slides the block up or down as the case may be, and thus varies the cut off. If required, the cut off may be fixed to any point, and the governor attached in the usual manner to the throttle valve.

Messrs. Barrows and Stewart, Banbury, showed a neat form of portable engine. The guide for the piston-rod crosshead is placed below, and consists of a flat bar planed on both sides, and clipped by means of a slide on the under side being bolted to the planed surface of the crosshead. This lower slide has a boss upon it, which carries the pump-rod, the pump being placed under the cylinder. The governor is upon the high speed principle being held by a spring, and altogether the arrangement appears to be compact, economical and thoroughly mechanical. Messrs. Tuxford and Sons show several of their portable engines of the usual upright cylinder description, which have now become so familiar. It is the fashion at the present time to run down anything but horizontal cylinders for portable engines, but we cannot see that they are in any way more effective than vertical cylinders while they are undoubtedly far less steady. Messrs. Robey and Co. have a very fine road locomotive fitted with Thompson's patent india-rubber tyred wheels. It is driven by a pair of inverted cylinder engines treble geared, and as it is altogether a first class job. We hope soon to give an illustration of it. They have also a small upright boiler and engine worth attention. The boiler is of the "pot" description, and the engine is fitted with their horizontal governor working on the main shaft. This system of governor was described last year, since which time, we understand that Messrs. Robey have made a great many, and that they have given complete satisfaction.

Messrs. Charles Powis and Co. exhibited a very well proportioned 10-h.p. horizontal engine with expansion gear worked by means of a separate eccentric, the amount of expansion being varied by means of a link interposed between the eccentric rod and valve rod. As, however, we intend giving an illustration of this engine, we will at present defer further remarks upon its merits.

Messrs. Fowler and Co. had as usual a fine collection of steam ploughing tackle and portable engines, amongst which may be mentioned an 8-h.p. traction engine and a 14-h.p. steam ploughing engine. The whole of the machinery exhibited by this firm appeared to be very well proportioned and adapted for hard work; the cylinders of the engines being steam jacketted, and those portions of the working parts most subject to wear being made of steel.

Messrs. John and Henry Gwynne, of Hammersmith, who are so favourably known for their centrifugal pumps, exhibited a very neat specimen of a portable steam pump. The engine and pump, which are similar to those usually made by them, are fixed upon a tank mounted upon wheels. This tank also carries a Field boiler, and as the great speed at which the engine runs is detrimental to the action of a free pump, the boiler is fed by a separate donkey engine fixed on the same frame. The whole arrangement makes a very compact job, which we intend to illustrate shortly.

Messrs. Marshall, Sons and Co., of Gainsborough, had attached to their portable engine a very simple arrangement for heating the feed water, of which we intend giving a sketch in a future number. Also a circular saw bench, with the set up slide so arranged, that when required,

the stuff may be sawn to any desired bevel. They also had a very neat upright engine and boiler, with a variable eccentric; and a very complete portable corn mill.

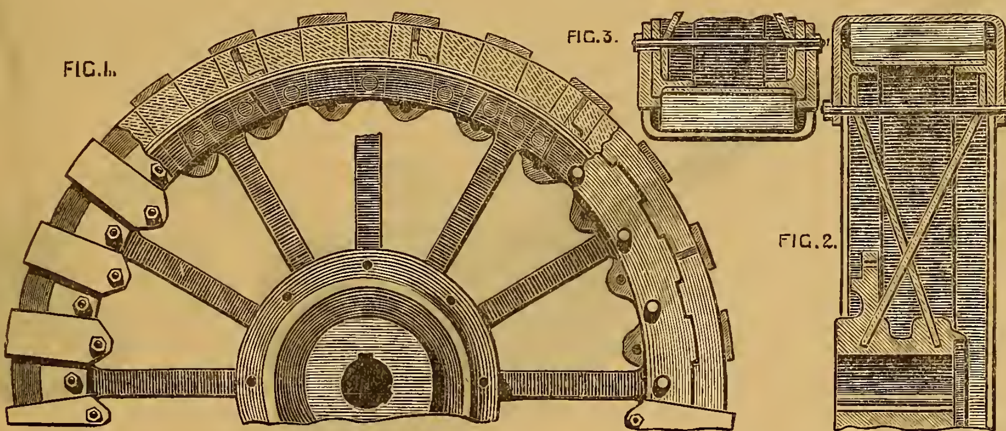
The Reading Iron Works had a large collection of machinery, amongst which was their prize 10-h.p. stationary engine, which performed so excellently at the Oxford trials. The arrangement of governor adopted by this firm, appears to be very simple and good.

Messrs. Ransomes, Sims and Head, had a very fine show of machinery, but nothing particularly new. We may mention, however, that their arrangement for heating the feed water by the waste products of combustion, combined with their system of double feed pumps, appears to be well adapted for working economically.

Messrs. W. and S. Eddington, of Chelmsford, exhibited an enormous traction engine, which although it was decidedly not handsome, had apparently done a considerable amount of work.

Near to this monster was a fine 20 ton steam road roller, by Messrs. Aveling and Porter, of Rochester. These rollers are now so well and favourably known, that we can only remark that this latest specimen fully sustained the reputation of that firm, for a branch of manufacture which they appear to have monopolised. This firm is also constructing traction engine wheels with india-rubber tyres upon the design patented by Messrs. Aveling and Greig, and illustrated in the accompanying engraving. The wheel is encased by 12 india-rubber segments, which

FIG. 1. FIG. 3. FIG. 2.



in this case are 12in. wide, by 3in. thick, each segment being held in its place by steel stirrups, 4in. wide, by ½in. thick, which pass over the india-rubber and rim of the wheel, and are secured by bolts passing through the wheel from side to side inside the rim, as shown in the sections, Figs. 2 and 3. The india-rubber segments are prevented from shifting round the wheel by being fitted in between transverse angle irons rivetted to the rim of the wheel, as shown in Fig. 1; while the stirrups, already mentioned, slide between guide pieces rivetted to the sides of the wheel rim, so that although free to move radially as the india-rubber is compressed, they are yet incapable of being canted circumferentially. The fact of the stirrups being thus supported enables them to resist the drag due to the exertion of the tractive power of the engine, and the india-rubber is thus relieved of this strain, and is made to act simply as a spring. The guide pieces between which the stirrups slide are not merely rivetted to the rim, but the latter is notched, and the guide pieces are made of such a section as to fit into the notches, as shown in Figs. 1 and 3.

Apart from the expense, these wheels have no doubt some advantage over rigid tyres, but as the cost of an engine with common wheels is only about half that of one fitted with india-rubber tyres, it is doubtful whether the slight advantage thus gained is not bought at too high a price.

Messrs. E. R. and F. Turner, of Ipswich, had one of the few novelties in the show, consisting of a self-acting variable expansion gear attached to a portable engine. As, however, the action of this arrangement would be better understood with the assistance of an illustration, which we hope to give next month, we will defer any description until then.

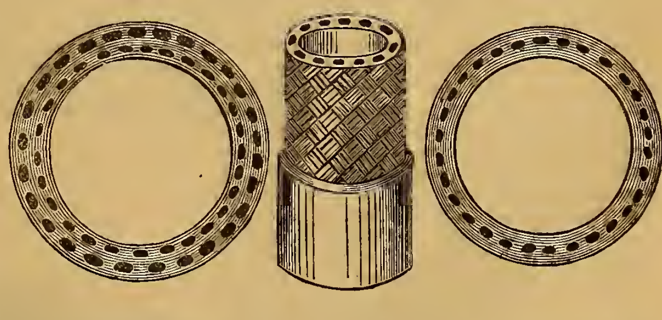
In the galleries of the Agricultural Hall there were assembled a great number of notions, but we failed to discover many that were new and at the same time useful. The first object that came under our notice was a very pretty little 1 H.P. engine and boiler, by Messrs. Riches and Watts. It was fitted with a high-speed governor, and altogether appeared to be well worth the moderate price (£45) asked for it.

A very simple mill bill was shown by Mr. T. L. Norton, of Mark-lane. The accompanying engraving shows a section of it, where it will be seen that the cutters are moveable, and easily sharpened or renewed as required.

Mr. W. G. Gibbs had a very complete set of models to illustrate, his system of harvesting in wet weather, and also for drying damp corn by means of passing it through a long heated air chamber; this chamber being made to oscillate so as to thoroughly mix the corn.

Messrs. Nicholson, of Newark, had a very nicely finished and compact upright engine and boiler with wedge-shaped guide for the piston-rod crosshead, adjustable by means of a screw. There was also a very good arrangement of high-speed governor attached to the engine, which we hope shortly to illustrate.

Mr. T. D. Eagles, of Fenchurch-street, had a nice compact upright engine and boiler on view, and also one of the few important novelties in the show. This consisted in a specimen of seamless vulcanised india-rubber tubing, which to all appearances was infinitely superior to the usual description. The accompanying illustration and description will



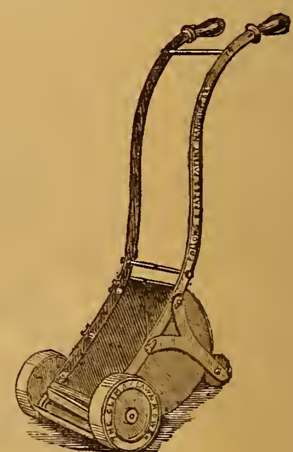
enable our readers to understand the method of manufacture:—In the manufacture of ordinary india-rubber and canvas hose the india-rubber is cut into strips of the required width to form the diameter of the hose, and is then lapped over a mandril and cemented together; over this tube of india-rubber is lapped a corresponding width of canvas, which is also cemented or gummed together, and this process is repeated according to the number of plys required. It will be evident that in this process a longitudinal seam runs the whole length of the hose, and is a source of weakness, as, when extra pressure is applied, the seam is liable to give way along its whole length. Now, in the Mr. Eagles' seamless hose, the process consists of first applying rubber in solution around an

elastic or other mandril, and afterwards (when the solution has solidified) braiding this over with either hemp or flax, as may be deemed best, in the same manner as a speaking tnbe is covered with worsted, viz., in a braid machine. After this another coating of rubber in solntion is spread over the fabric, and so on according to the number of plys required, In the ordinary lists circulated for common hose will be seen—"1 ply for light-conducting purposes; 2 ply for small pressures up to 23lbs.; 3 ply to 45lbs.; 4 ply and upwards for large pressures." In Mr. Eagle's seamless hose 1 ply is warranted to 400lbs., and the only reason why 2 ply is made is to gain substance, not to gain strength, as the 1 ply is amply strong for any reqnired purpose. For snction the 2 ply is stout enough to dispense with spiral wire. The hose also does not flatten at the bends like common hose, For coal-cutting machines, worked from the bank either by compressed air or hydraulic power, it is also said to be specially suitable.

Messrs. Follows and Bate, of Manchester, exhibited several of their new lawn mowers, which are decidedly the simplest we have yet seen. The accompanying engravings of the "Climax" and the "Anglo-American" form withont the aid of weighted valves, accumnlators, or other costly machinery usnally employed to keep np a continuous nniform pressure for any length of time.

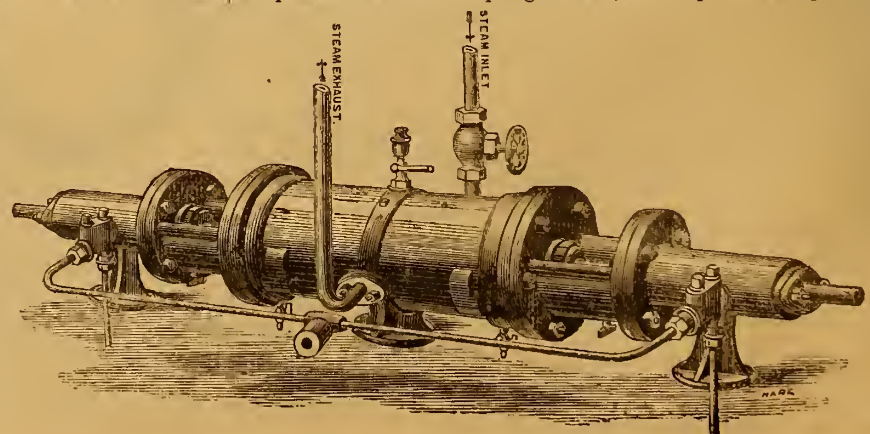
Messrs. Tangye, Bros. and Holman, had as usual, a splendid collection of their engines, of which we understand they have made an enormous number since the previous cattle show.

THE PHAETON PEN.—Messrs. Macniven and Cameron have just brought out a new pen, which in our opinion, is even superior to either the "Waverley," the "Owl," or the "Pickwick," already prodnced by the same firm. The form of this description of pen is, as probably most of our readers are aware, entirely different from the usual steel pen, inasmuch as the extreme end of the nibs turn slightly upwards instead of downwards. The advantage of this peculiarity is, that while possessing all the merits of the usual shaped pen, it entirely prevents that unpleasant scratchiness so provoking to fast writers. We think that the Phaeton pen may be fairly entitled to be called the editor's friend.



lawn-mower sufficiently illustrate the principle. It will be seen that in the "Climax" the gearing is redнced to a simple wheel and pinion working direct, the collecting box being placed behind instead of in front of the machine. The "Anglo-American" mower is not provided with a collecting box, as it is intended to be used on the American principle of scattering the cut grass over the lawn, and thereby providing nourishment for the growing grass. As might be expected, the extreme simplicity of these mowers enables the makers to supply them at a very moderate price.

Messrs. Hayward Tyler and Co., of Upper Whitecross-street, London, had a very fine collection of pumping machinery, including their well known "universal" pump. Amongst the novelties in this collection was a modification of this pump for the purpose of working hydraulic presses, and for which it appears to be pecnliarly well adapted. From the accompanying illnstration, it will be observed that the steam cylinder is placed in the centre, the piston-rod projecting through both ends of the cylinder, each end of which works a hydranlic pump. The respective diameters of the cylinder and pumps are so proportioned, that when the extreme pressure to which it is desired to work the presses is obtained, the engine is pulled np. Upon first starting the pump, when, of course, there is no pressure in the hydranlic cylinder, the pump works very rapidly, but as tho pressure accumulates the speed decreases, until, when the desired pressuro is attained it stops altogether. As, however, the steam-cock is left open, as soon as the pressure slightly decreases, the pump again starts until the pressure is brought up. By this means the pressure is always kept uni-

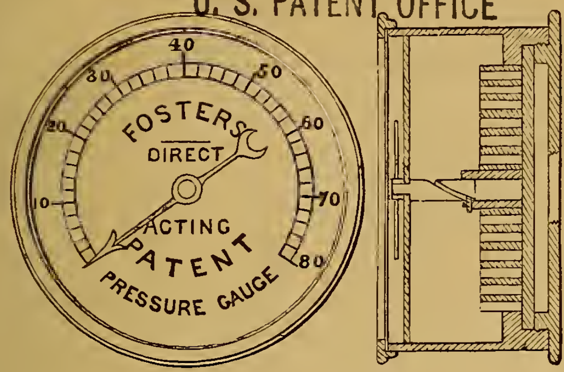


FOSTER'S DIRECT-ACTING PRESSURE GAUGE.

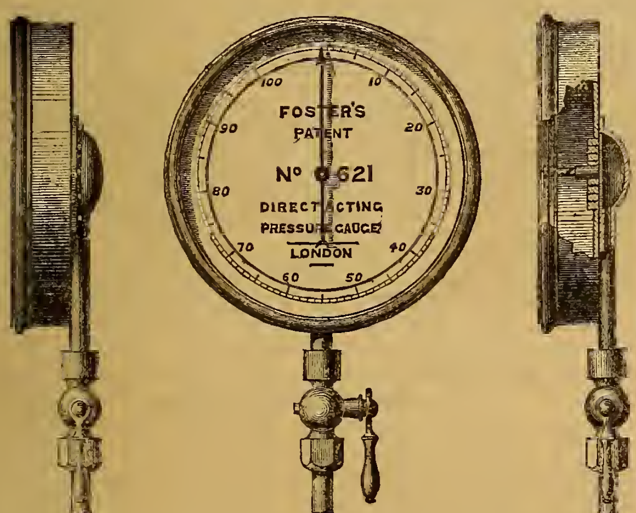
We give an illustration below of a new description of pressure gauge, which is decidedly the simplest we have yet seen, there being no tubes, racks, pinions or quadrants nsed in its constrnction.

As shown by the sections, the action indicated by the hand is taken from a spring or plate at the back, parallel to the dial; the means of communication between the spring and hand is merely a screw-slotted spindle. Fixed to the centre of the spring or plate is a tnbe which has a small pin fixed in its side, this pin fits the slot in the spindle: now, as the pressure deflects the spring forward, so the pin slides up the slot,

and canses the hand to revolve, the reverse action taking place when the pressure is removed.



Amongst other advantages of this arrangement it may be mentioned, that very small ganges may be constructed with eqnal facility and withont affecting their accuracy. Thus the drawing below illnstrates the fnll size of one of these ganges suited for carrying abont in the pocket, and intended for the use of boiler inspectors, civil engineers, &c., the total weight of such an instrument being only twelve ounces.



THE AMERICAN NAVY.

The report of Hon. George M. Robeson, secretary of the navy, sent to Congress with the president's message in December, does not give a very favourable impression of the American navy. The general naval force of the country remains in much the same condition as last year, being, however, somewhat redneed in accordance with the desire of the Congress. The American naval forces on the European and Asiatic stations are said to be totally inadequate. In view of European complications and the hostile attitude of China and Japan, the United States is but scantily represented there, its commercial interests being weakly protected by 17 vessels carrying only 145 guns. On the 140,000 miles of navigable waters over which American commence courses, there are stationed bnt 37 war vessels mounting only 350 guns, aggregating 40,000 tonnage. Cruising upon the same seas and with dnties not more varied, England has 191 ships with 328,000 tonnage. The position of America on the seas, it is shown, is inferior to that of even third and fourth class European Powers. There is also said to be the same defect in the efficiency as in the numbers of the navy. There is great disadvantage in relying wholly on steamers for cruising purposes. Most steamers can carry only ten days' coal, and the greater portion of their time is consnmed in seeking supplies. The nselessness of the *Monitor* iron-clad fleet, excepting for purposes of home and harbonr defence, is also shown, and it is remarked that they could be very little relied npon if brought in contact with the powerful ironclads of European navies. Congress is recommended to build immediately a number of iron war vessels that will have the ability to properly represent the American Government abroad and to protect its interests. This is strongly nrged in view of the present condition of Europe. In the present state of the navy what commerce America has is scarcely protected, while in the East the American flag secures no respect save through diplomatic interference. Semi-barbarons nations so far away as China and Japan can only get an idea of the power of the United States through its vessels of war. The argument of force is the only one they can or will understand. This is also trne to a great extent in Europe. The people there have no visible manifestation of the power of the United States. In the event of a war or of a sudden emergency calling for prompt action, American ships would either be uselessly sacrificed or compelled to seek safety in neutral ports. The disturbed condition of Europe ought to a great extent to give the world's carrying trade to American vessels, and our commerce should be given the protection its importance demands. An army could be raised by proclamation in a few weeks, bnt years are required to build ships for an efficient navy such as the wants of the country make necessary. The report states that this efficiency of the navy has an important connection with American inflnence in the waters of the American continent. This Government cannot exert its proper inflnence in the surrounding countries and islands without being better represented on the seas. Spain is mnch better prepared in this respect than the United States. This country is in no oondition to enforce a policy or a treaty with any outlying island. Troops enough could be raised, but the means of transportation would not be forthcoming. The navy is limited to 8,000 men, and the Secretary will urge that this limitation be extented to at least 12,000 men. This will enable the Department to increase the nnmber of ships in commission. He will also recommend that lines of ocean-going steamers be established carrying the American flag, which could always be available to the Government as a naval force in time of need. The question of jurisdiction over waters adjacent to the American coasts will also be discussed. The rule obtaining in the Irish Sea gives complete jurisdiction over it to one Government. But the marine league restriction of jurisdiction is strictly applied in the Gulf of Mexico, the commerce of which is almost wholly American, mnch to the inconvenience of shippers; and all the immense volume of commerce flowing from the Atlantic States to the Gulf is obliged to pass throngh waters over which Spain has jurisdiction.

The above report treats of the American navy. Another annnal report, that of the Statistical Bnrean, treats of the merchant marine. The total number of vessels employed in the foreign and domestic trade of the United States is 28,138, aggregating 3,946,149 tons. This, as compared with 1860, ten years ago, when the aggregate tonnage was 5,353,868 tons, shows a falling off of over 26 per cent, Of the present marine, 16,995 vessels, with 2,135,263 tonnage, are sailing vessels; 3,341, with 1,015,075 tonnage, are steam vessels; and 7,802, with 795,805 tonnage, are unrigged barges and boats. There are over five times as many sailing vessels as steamers, although the sail tonnage is but donble the steam tonnage. It is curious to note the distribution of this fleet. Maine has 2,972 sailing vessels and only 46 steamers, a disparity owing to her large fishing fleets. Massachusetts, owing chiefly to the same canse, has 2,795 sailing vessels to 82 steamers. Gloucester, the leading Massachusetts fishing port, owns 560 sailing vessels of 28,547 tons, and only one little steam-tug boat of 13 tons. The great whaling port. New Bedford, has 288 sailing vessels, of 59,641 tonnage. In Boston, although it has considerable foreign trade, the proportion is 817 sailing vessels to 63 steamers, and 259,804 tonnage for the former to 22,020 for the latter. New York has 2,460 sailing vessels, with 473,451 tons; 655 steamers, with 311,890 tonnage; and 1,487 unrigged vessels, with 183,586 tonnage. The Western rivers employ 725 steamers, with 206,189 tonnage, and 843 unrigged vessels, with 120,288 tonnage. There are no sailing vessels there. This is exclusive of the New Orleans district, where there are 400 sailing vessels with 14,252 tonnage, and 170 steamers with 41,788 tonnage. The commerce of the Lakes employs 1,548 sailing vessels, with 252,453 tonnage; 641 steamers, with 142,474 tonnage; and 3,154 unrigged vessels, with 285,535 tonnage; the whole Lake fleet aggregating 5,343 vessels, with 680,462 tonnage. On the Pacific coast there are 802 sailing vessels, with a tonnage of 88,946; and 197 steamers, with 53,088 tonnage. The heavy loss in American tonnage since 1860 is attributable to two canses—the substitution in inland traffic of railways for water transportation, and the absorption by foreign vessels of a large portion of our foreign ocean commerce. The first cause is natural and involves no national loss. With the complaint abont the second canse and the ineffectnal attempts constantly made to remedy it the world is familiar.

OBITUARY.

THE LATE MR. BRASSEY.

The announcement that this eminent man died somewhat suddenly on the 8th ult., at St. Leonard's-on-Sea, where he had recently been staying for the benefit of his health, will create a deep feeling of regret among that large circle to whom his virtues and estimable character were known. Mr. Brassey has suffered from periodical attacks of asthma for some years, and within the past few months his health has given some anxiety to his friends. But even so recently as Wednesday the 7th ult. he had projected a journey to Preston hall, near Maidstone, the seat of his second son, Mr. Harry Brassey M.P. for Deal, and his death which occurred at half-past four on the next day, occasioned very painful distress to those members of his family by whom he was surrounded. Thomas Brassey was born in 1805 at Buoghton. in Cheshire, where his yeoman father occupied land which had been held by his ancestors during a couple of centuries. Articled to a local land agent and surveyor, Mr. Brassey here learnt the principles of commercial economy and made his first independent start by contracting for the making of a road in North Wales.

The first railway contract signed by Mr. Brassey was in 1836, when he took ten miles on the Grand Junction line between Birmingham and Liverpool, now incorporated with the London and North-Western Railway. The Penkridge Viaduct on the same line was his next great work, and at this date Mr. Brassey accompanied the late Mr. Locke, the eminent engineer, into the southern districts of England, where he executed large portions of the main South-Western line, and many of its branches. From the south-west district of England Mr. Brassey was naturally led by the same engineer to the Continent, where in the early day of improved locomotion he constructed a large portion of the Western of France and the Paris and Rouen Railways, which in turn led to his contracting for important works in Belgium, Holland, Denmark, Norway, Spain, Savoy, Italy, and Austria, with all of which countries his name will ever be intimately associated. Many of these works—notably, among others, the flying railway over Mont Cenis—proved in a pecuniary point of view disastrous speculations to Mr. Brassey, but such was the largeness of the view he took of everything upon which he was engaged, and such his steadiness of purpose and integrity, that, although in numerous cases where through failure of periodical payments it would have been easy to have relieved himself of unprofitable contracts, he never would avail himself of the *laches* of others, and if his word had once been passed he always insisted upon carrying out his engagements to the letter. This was his course of conduct when, during the panic of 1866, he found himself associated with Messrs. Peto and Betts in many large works, which at that period were paralyzed for want of capital. On the collapse of his partners in these undertakings Mr. Brassey spontaneously took upon himself all the works with which his name had been connected, and personally carried them through to completion.

The gigantic foreign and colonial operations in which Mr. Brassey was engaged for many years did not exhaust his energy, and while they were in progress a section of his large staff were always busy in the United Kingdom—at one time upon the Caledonian Railway, a remarkably difficult work, at another constructing the Welwyn Viaduct upon the Great Northern Railway; then the West London Extension line, including a bridge across the Thames at Battersea; then the Northern midlevel sewer, and more recently Mr. Baker's great bridge across the Mersey at Runcorn, near Liverpool. A fair idea of the magnitude of Mr. Brassey's operations may be gathered from the fact that in the 13 years from 1848 to 1861 inclusive, he made, either by himself or in association with others, 2,374 miles of railway, at a contract price of £27,998,224.

Mr. Brassey is stated to have suffered during the panic of 1866 to the extent of more than a million of money, but it is, perhaps, quite as extraordinary that in 1869 he is understood to have been a richer man than during any former period of his career. His existing contracts are now gradually running out. Indeed, his chief motive for continuing his business during recent years has been his knowledge of the fact that he had a very large staff dependent upon him, and that he did not like to see them out of employment. His loss will be greatly felt among his own class, whom he was never tired of assisting in the manner best calculated to be useful to themselves. Mr. Brassey married early in life Miss Harrison, of Birkenhead, who survives him, and by whom he leaves three sons, Mr. Thomas Brassey, M.P., for Hastings, who married the daughter of Mr. John Allnutt, and resides at Normanhurst, near Hastings, purchased some years since from Sir Peregrine Acland; Mr. Harry Brassey, M.P. for Deal, who is married, and resides at Prestonhall, near Maidstone; and Mr. Albert Brassey, of Heythrop, in Oxfordshire, who is unmarried, and an officer in the 14th Hussars.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Four large steamers, valued in the aggregate at 320,000 dols., were destroyed by fire at Evansville, Indiana, on the 21st of November. A large amount of goods upon them was also burnt, and a lady, a passenger on board one of the steamers, perished in the flames.

The streets of New York are lighted by 18,017 gas burners, owned by the different companies as follows:—Manhattan, 7084: New York, 3241; Harlem, 4000; Metropolitan 3692. Each burner consumes 3ft of gas per hour, and burns 3833 hours and twenty minutes per year. The price paid the companies is 53 dols per annum for each lamp. Each lamp-post cost the city 20 dols., and each lamp 4·50 dols, to construct. The number of feet of gas burned per annum by the city in lighting the streets is 134,360,483; the cost of material is 441,416· 50 dols.; the annual cost of gas is 954,001 dols. The Manhattan Company has two hundred miles of main pipe; the New York, one hundred; the Metropolitan, ninety-five; and the Harlem, ninety-eight.

Although the 15th ult was the date fixed for the public trials of the agricultural machinery forwarded to the Cordova Exhibition, it is now notified that implements arriving later will be privately tried, and allowed full rights of participation in the ultimate awards of the jury after the opening of the Exhibition in March next. Intending British exhibitors should immediately address their applications to Messrs. J. M. Johnson and Sons, of Castle Street, Holborn, London.

Two extensive labour strikes have occurred in the United States. One is among the coal-miners of the Scranton coal region in Pennsylvania to prevent a reduction of wages which has stopped work at a large number of collieries, and continues without any prospect of settlement. The employers, who have a large stock of coal on hand, with a falling market, are said to be rather pleased that the strike occurred, and there is a belief that, as is often customary in these coal-miners' strikes, there has been collusion for the purpose of producing a scarcity and raising the price of coal, the employers devoting a fund to help to support the colliers. In New York city the shoemakers have struck to prevent a reduction of their wages of 15 per cent. As with the coal-dealers, the employing shoe manufacturers in New York have a large stock on hand and hence will not yield, so that this strike, like the other, shows no prospect of adjustment.

MILITARY ENGINEERING.

An order has lately been received at the Fort Pitt foundry, Pittsburg, Pennsylvania, from the Navy Department, for twelve 15-inch guns. The first two are to be cast from the same run of metal—one hollow on the Rodman principle, and the other solid, after the Dahlgren plan—and these, when finished, are to be subjected to an extra proof of 500 charges each, for the purpose of testing the endurance of each class of gun. This will be the first time in the history of ordnance manufacture when a gun of 15-inch calibre has been cast solid, and the results will be watched for with considerable interest by scientific men. If the new principle of construction is approved, it is probable that the Government will man the principal forts in the country with guns of this calibre and made after this plan. Recently two officers of the Spanish navy arrived in this country empowered to negotiate for the purchase of large guns for Morro Castle, in the harbour of Havannah. These officers contracted with the Fort Pitt Foundry for the construction of 16 15-inch and four 20-inch guns for that famous castle. These cannon are now being completed, and will be delivered in New York in the course of a couple of months. The manufacture of guns of extremely large calibre, which was brought to great perfection during the war of the Rebellion, is still carried on at the Fort Pitt Foundry and arrangements will soon be perfected by which guns capable of throwing a larger weight of metal than has ever been projected by powder can be cast and finished in a most perfect manner. It will be remembered that the 15-inch cannon which were used on our Monitors during the war were the objects of the greatest curiosity, and when the first 20-inch gun ever cast was mounted at Fort Hamilton, hundreds of our citizens made the journey to see it. If these enormous cannon were regarded with so much curiosity, what will be thought of 30-inch guns—havng inside space enough for a small couple to dance a minuet in—mounted on a fortification? Major Rodman, the distinguished ordnance officer and the inventor of the Rodman gun, has long entertained the idea that 30-inch guns could be made with almost the same facility as 20-inch could, and he is now arranging for an appropriation to enable him to carry his plan into execution. If he succeeds, the patterns will be made immediately, and very soon thereafter the wonder of the world, in the form of ordnance, will be cast. As 20-inch guns cost about 30,000 dols. each, doubtless 30-inch pieces will cost at least double that sum.

TELEGRAPHIC ENGINEERING.

The report of the British Indian Submarine Telegraph Company (limited) presented on the 15th ult, states that from the 25th of March last, when the line was successfully laid, the gross revenue to September 30 amounted to £50,158. and the expenses to £16,976, leaving as net profit £33,182, and recommends a dividend of 5s. per £10 share for the six months and five days' working, which will absorb £29,687, leaving £3,494 to be carried to reserve. It was anticipated that the Extension Company's line from Madras to Singapore would be laid by the end of the month and that the lines to Australia and China will be completed this year and bring large accessions of traffic. In consequence of the railway through Egypt having been removed to a new route *viâ* Benha and Zagazig to Suez, the Company have obtained a concession from the Khedive to erect a telegraph line thereon, thereby securing an efficient duplicate land line easily maintained. On the 24th of September the cable parted in the Gulf of Suez, and owing to rough weather could not be repaired until the 13th of October.

STEAM SHIPPING.

The John Elder belonging to the Pacific Steam Navigation Co., proceeded over to the Gareloch on the 3rd. ult., to adjust her compasses.

SHIPBUILDING.

Messrs. Samuda Brothers, shipbuilders, of the Isle of Dogs, have nearly completed three iron vessels on Russian account. It is stated that these ships are intended for commercial purposes, but it would appear that they could be easily converted into men-of-war.

The Birmingham Canal Navigation Company have just had a steam launch built by Messrs. Yarrow and Hedley, for the use of the authorities when inspecting the canal. This little craft left Messrs Yarrow and Hedley's works at Poplar, London, on Wednesday, the 7th ult., and arrived in Birmingham all safe on the Saturday following having passed through no less than 191 locks.

Mr. Hadnan has we understand made a design by which a low freeboard turret ship like the *Captain* may be made to cruise in rough weather under sail without endangering her safety, as in the late lamentable loss of Her Majesty's ship. This object, it may be briefly explained, is met by first widening the hurricane deck (the evidence before the Court-martial on the *Captain* proving that her deck was too small to work her sails efficiently), and then raising from the fighting deck false sides or bulwarks to meet the hurricane deck when widened. This gives a freeboard of 17ft. instead of six, and an angle of 35 degrees instead of 14, and yet the ship when required for action is precisely the same as the late *Captain*, but when required as an ocean cruiser she has the increased freeboard and angle of immersion of the upper deck.

LAUNCHES.

THE ceremony of launching the new paddle-wheel despatch vessel *Lively* from the building slip in Sheerness dockyard was performed in a most successful manner on the 10th ult. The *Lively* was commenced in April last, and her dimensions are as follows:— Length over all, 234ft. 6in.; length between perpendiculars, 230ft.; length of keel for tonnage, 28ft. 1½in.; extreme breadth, 28ft. 3in.; breadth for tonnage, 28ft. 1½in.; breadth moulded, 27ft. 3½in.; breadth outside paddleboxes, 48ft. 6in.; depth in hold, 14ft. 6½in.; burden in tons, o.m., 842 31-94; registered tonnage by Merchant Act, August 10, 1854, 1,099 79-100. The vessel is wooden-built of three thicknesses of plank the two inside built diagonally, and the outside put on longitudinally, and she is expected to be the fastest vessel of the Salamis class. The *Lively* will carry two guns and engines of 250-horse power. Immediately upon being launched she was taken into the basin to be fitted for commission.

THERE was launched on the 12 ult. from the Fairfield shipbuilding yard, of Messrs. John Elder and Co., an iron screw steamship of 1975 tons, B.M. and 350 horse power nominal, and of the following dimensions:—Length between perpendiculars 230; breadth 38ft.; depth moulded 24ft. 3in. As she left the ways she was gracefully christened the *Coquimbo* by Miss Langley of London. The *Coquimbo* has been built to the order of the Pacific Steam Navigation Co. of Liverpool, and is intended for their passenger and their cargo carrying service on the West Coast of South America. The builders have three steamships on the stocks for the same owners, viz., the *Cuzco*, *Chimborazo*, and the *Aconcagua*, each of 3,200 tons, B.M. and 500 horse power nominal.

ON the 26th. November there was launched from the Fairfield Shipbuilding Yard of Messrs John Elder & Co., an iron screw steamship, of 936 tons B.M. and 175 horse power nominal, and of the following dimensions:—Length between perpendiculars, 220 ft.; breadth 29ft. 6in.; and depth moulded, 23ft. 4½in. As she left the ways she was gracefully christened the *Verite*, by Miss Gillan. The *Verite* has been built to the order of Messrs. N. Paquet & Company of Marseilles, and is intended for their Mediterranean trade.

MESSRS. THOMAS WINGATE & Co. Whiteinch, launched on the 26th. Nov. a screw steamer of 170 tons B.M., fitted with engines of about 60-horse power. This vessel has been built to the order of Mr. James Hamilton, of this city, and is of wood construction. She is intended for service in the Bay of Valparasio and is fitted with large water tanks for supplying vessels in the Bay with fresh water, and also in case of emergency to act as a fire engine; for this purpose she is fitted with a very powerful steam pump, capable of discharging 72,000 gallons per hour, and adapted to draw water either from the tanks or from the sea as required. She has also a distilling apparatus for fresh water, and two powerful steam winches, one of the latter—capable of lifting 20 tons—being intended for raising ships, moorings, &c. The vessel is also adapted for towing purposes is built to highest grade of classification at Lloyds, and is fitted with Morton's patent condenser. Altogether she is a most useful craft, and we have no doubt that such steamers would be found of great benefit at many foreign ports where vessels have to lie at a distance from the shore. The ceremony of naming her *Princess Louise* was performed in the most graceful manner by Miss Mary Guthrie, of Paisley. The *Princess Louise* proceeds to Valparaiso in a few days, under command of Captain James Craig. Her construction, which has occupied only two months, has been superintended by Mr David Campbell, engineer, of this city.

ON the 24th October, the first ship built in the new shipbuilding-yard of Messrs. Alexander Stephen & Sons at Linthouse was successfully launched. Miss Drummond, of Stirling, named the vessel *Glendarroch*. The length is 265 ft., breadth of beam 33 ft., depth of hold 24 ft. 8 in. and the tonnage 1500. The vessel will be engined by Messrs. J. and J. Thomson, of Finnieston. In the same yard, on the stocks, is a sister vessel. With respect to the yard itself, it may be mentioned that the ground was broken in April 1869, and consists of 32 acres, it has a frontage to the River Clyde, and would admit eight vessels to be built simultaneously. The firm had to remove to their new premises in consequence of their lease at Kelvinhaugh expiring in May next, and of the operations of the Clyde Trust. The new yard is four times the size of the old one. The machinery shed has a frontage of 400 feet by 200; the smithy 100 feet by 230; the joiners' shop and moulding loft 260 feet by 66. It has also a forge which will contain two steam-hammers and puddling furnaces, and indeed all the latest improvements.

TRIAL TRIPS.

THE new paddle-steamer *Maitland* built by Messrs. M'Culloch, Paterson & Co. for the Australian coasting trade, proceeded on her trial trip with a select company on board. The *Maitland* is a handsome paddle-steamer with hurricane deck, and all the latest improvements.

RAILWAYS.

THE proposed transfer of the station of the Great Western and other railways converging at Birkenhead from Monks' Ferry to the more central point of Woodside involves considerable changes, of which some are set forth in detail in the plan of the Great Western Company. A line is to be constructed from the point where the company's railway crosses that of the London and North-Western at, say, 45 yards south of the tunnel at Monks' Ferry, continuing from that to a terminal point between the approach road to the Woodside landing-stage and the river, and between the workshops of the Birkenhead Commissioners and the shipbuilding yard of Messrs Clover and Co. There will also be a road made from Rose Brae, on the west, to within about 40 yards of where Chester-street joins Church-street. Public traffic will be discontinued on the Rose Brae road wherever it may interfere with the new works of the company. The undertaking for joining Liverpool and Birkenhead by means of a railway under the Mersey is again revived. Powers are to be sought in the next Session by the Mersey Railway Company (who in 1866 obtained certain authority for the project) to vary to some extent their original plan. The noticeable variations in the modified scheme appear to be, in Liverpool, the construction of an underground line from the north-east corner of Paradise-street and the south-west corner of Church-street to the Roscoe Arcade, where the Central Railway Companies' line crosses it. At the other side of the water the submarine line will emerge near the south side of the bridge which carries the Birkenhead joint railway over Green-lane.

THE Glasgow City Union Railway commenced to run passenger traffic on the 12th. ult., and although the weather was very unfavourable, large numbers of persons availed themselves of the new line, which is now in excellent working condition. There was a preliminary demonstration on the 10th. ult., when the directors along with a number of gentlemen holding official positions in the city went over the line. The Dunlop-street station, from which the train started, was examined with much interest, and afforded a theme for general admiration. About this station there are several remarkable engineering features. Considerable ingenuity has been displayed in supporting the arches underneath the line, and in obtaining as much light as possible. A hydraulic lift is conveniently situated for taking up passengers' luggage, a second lift of smaller construction being used in connection with the parcels' office. The station is heated throughout with hot water apparatus, and there are six lines of rails with two arrival and two departure platforms inside. These, like all the other platforms on the railway, have been laid down with Val de Travers asphalte. It is hardly necessary to add that the utmost satisfaction was expressed with the whole arrangements of the line.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	From s.	From d.	To £	To s.	To d.
COPPER.						
Best selected, per ton	73	0	0	,,	,,	,,
Tough cake and tile do.	71	0	0	,,	,,	,,
Sheathing and sheets do.	73	0	0	74	0	0
Bolts do.	74	0	0	,,	,,	,,
Bottoms do.	74	0	0	76	0	0
Old (exchange) do.	62	0	0	,,	,,	,,
Burra Burra do.	73	0	0	71	0	0
Wire, per lb.	0	0	10	,,	,,	,,
Tubes do.	0	0	10½	0	0	10¾
BRASS.						
Sheets, per lb.	0	0	7½	0	0	7¾
Wire do.	0	0	7	0	0	7¼
Tubes do.	0	0	9½	0	0	10¾
Yellow metal sheath do.	0	0	6¾	0	0	7
Sheets do.	0	0	6¼	0	0	6⅜
SPELTER.						
Foreign on the spot, per ton.	17	10	0	18	0	0
Do. to arrive.	,,	,,	,,	,,	,,	,,
ZINC.						
In sheets, per ton	21	0	0	22	0	0
TIN.						
English blocks, per ton.	130	0	0	,,	,,	,,
Do. bars (in barrels) do.	131	0	0	,,	,,	,,
Do. refined do.	135	0	0	132	0	0
Banca do.	130	10	0	131	0	0
Straits do.	130	10	0	131	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	5	0	1	8	0
IX. do. 1st quality do.	1	12	0	1	14	0
IC. do. 2nd quality do.	1	5	0	1	6	0
IX. do. 2nd quality do.	1	11	0	1	12	0
IC. Coke do.	1	2	6	1	3	6
IX. do. do.	1	8	6	1	9	6
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	2	6	,,	,,	,,
Do. to arrive do.	7	0	0	,,	,,	,,
Nail rods do.	7	10	0	,,	,,	,,
Do. Stafford in London do.	7	15	0	8	0	0
Bars do. do.	8	2	6	9	0	0
Hoops do. do.	8	15	0	9	0	0
Bars do. at works do.	7	15	0	8	0	0
Hoops do. do.	8	2	6	8	5	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	0
Bars, common, do.	6	5	0	6	7	6
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	0	0	6	5	0
Do. Swedish in London do.	10	5	0	10	10	0
To arrive do.	10	0	0	,,	,,	,,
Pig No. 1 in Clyde do.	2	12	0	3	0	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	10	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	,,	,,	,,
English spring do.	17	0	0	,,	,,	,,
QUICKSILVER, per bottle	12	10	0	,,	,,	,,
LEAD.						
English pig, common, per ton.	18	2	6	,,	,,	,,
Ditto L.B. do.	18	5	0	18	7	6
Do. W.B. do.	19	10	0	20	0	0
Do. sheet, do.	19	0	0	,,	,,	,,
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	21	0	0	,,	,,	,,
Spanish do.	17	15	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

DATED NOVEMBER, 19TH, 1870.

3032 R. Drury—Improved jewel box
3033 H. Tylor—Construction of frames for bedsteads, &c.
3034 L. F. Boileau—Fan punkahs
3035 G. M. Felton—Shirt collars
3036 J. R. Sawyer—Preparation of printing surfaces in photo-mechanical printing
3037 W. R. Lake—Machinery for scouring, &c.

DATED NOVEMBER 21st, 1870.

3038 J. C. Edwards, and J. Taft—Machinery for preparing and washing wool, &c.
3039 J. W. Butler—Application of concrete to structures, &c.
3040 V. de Tivoli—Ship signals
3041 E. Toynbee—Improvements in screens
3042 A. C. Tupper—Manufacture of lint for surgical, medical, and other purposes
3043 E. Langlet—Apparatus for preventing steam-boiler explosions
3044 W. H. Fletcher—Manufacture of cambrics
3045 J. Hargreaves—Manufacture of sulphates of soda and potassa
3046 Sir E. Fitzmaurice—Arrangements of forts or towers and in the mode of working the guns therein
3047 J. Hargreaves—Apparatus employed or used in the manufacture of sulphates of soda and potassa
3048 C. H. Southall and J. Blakey—Improvements in self-acting machinery for making and finishing boots and shoes
3049 A. V. Newton—Condensers for steam pumps
3050 J. H. Johnson—Breech-loading firearms

DATED NOVEMBER 22ND, 1870.

3051 F. Lee—Improved trace attachments for artillery and other harness
3052 W. Gardner and J. Russell—Improvements in shirts
3053 W. N. Nicholson and E. Laurence—Governors for steam, &c.
3054 R. Brown—Improvements in furnaces
3055 C. S. Royle—Apparatus for felting hat bodies, &c.
3056 A. H. Watkins—Improved respirator
3057 T. G. Walker — Expelling volatile matters from peat, &c.
3058 A. V. Newton—Bearings for carriage axles
3059 J. G. Tongue—Looms for weaving

DATED NOVEMBER 23RD, 1870.

3060 W. R. Pook—Ventilating sewers
3061 W. R. Lake—Lighting apparatus
3062 W. R. Lake—Gas-regulating apparatus
3063 W. G. Eavestaff—Pianofortes
3064 A. V. Newton—Securing screw nuts, &c.
3065 A. V. Newton—Brushes
3066 J. Baker—Combined winnowing, &c.
3067 J. H. Johnson—For carrying liquid cargoes in bulk
3068 R. Banton—Castors for furniture, &c.
3069 Sir W. Thomson—Electric telegraph transmitting, &c.

DATED NOVEMBER 24TH, 1870.

3070 H. Codd—Improvements in bottles
3071 C. M. Joseph—Filters
3072 E. Barker—Lockets, &c.
3073 W. Andrews—Elevators for stacking hay, &c.
3074 W. L. Joy—Charging oil-seed presses, &c.
3075 H. H. Henson—Manufacture of fences, &c.
3076 W. F. Read—Purifying beer
3077 S. Johnson—Velocipede carriages, &c.
3078 W. Nunn—Means of advertising
3079 W. Nunn—Traps to drains, &c.
3080 W. Prangley—Portable waterclosets
3081 J. Penn and W. Hounsell—Curved metal pipes
3082 E. H. Griffiths — Railway carriage lamps, &c.
3083 J. B. Wayne — Breech-loading firearms
3084 S. J. V. Day—Hydraulic presses for pressing cotton, &c.
3085 W. Beardmore—Certain furnaces used in the manufacture of iron
3086 J. H. Johnson—Earth closets
3087 G. Haseltine — Manufacture of iron and steel, &c.
3088 G. Haseltine—Carpet linings and stair pads
3089 G. Haseltine—Boots and shoes
3090 P. Lennox—Combined instrumentalities for imparting horizontal reciprocating movements to a pendulous rod or suspensory

DATED NOVEMBER 25TH, 1870.

3091 F. L. Roveding and H. Boucher—Mamufacture of faggots, &c.
3092 W. Carter—Manufacture of nets used for ladies' hair
3093 H. Larkin—Manufacture of chlorine
3094 J. Robinson and J. Peel—Looms for weaving
3095 J. Whittaker—Machinery for forging or manufacturing untapped nuts
3096 J. Perrett — Construction of bow or projecting windows
3097 H. Allen—Breech-loading fire-arms
3098 S. Desborough—Manufacture of soap, &c.
3099 T. C. Hinde—Manufacture of iron and steel
3100 S. Gardiner—Machine for hulling, &c.

DATED NOVEMBER 26TH, 1870.

3101 S. Bowen — Machinery employed in the manufacture of sheet glass, &c.
3102 W. Richard, J. Richard and W. M. Richard—Machine printing
3103 J. O. Spong — Apparatus for cleansing and polishing forks, &c.
3104 V. D. de Michele—Apparatus for ascertaining the breaking strain of concrete, &c.
3105 W. G. Gard—Preserving meat, &c.
3106 R. Brown—Miners' safety lamps
3107 A. Bryant and S. A. Culley—Deodorizing and treating sewage
3108 H. H. Murdoch—Locks and padlocks
3109 C. T. Shaw—Bracelets
3110 R. A. Hardcastle—Moving or transporting heavy bodies
3111 S. J. V. Day—Dressing yarus or warps

DATED NOVEMBER 28th, 1870.

3112 J. H. Johnson—Mnnufacture of corrugated and embossed glass
3113 W. Milburn—Lawn-mowing machines
3114 C. D. Abel—Locks and latches
3115 C. D. Abel—Locks and latches
3116 C. E. Green and J. Green—Breech-loading fire-arms
3117 B. J. B. Mills—Automatic ventilator, alarm, and pump for vessels
3118 J. Purdey—The action of breaking down guns with a snap fastening
3119 H. H. Bigg—Construction of mitrailleurs or machine guns
3120 W. R. Lake—Couplings for railway carriages

DATED NOVEMBER 29th, 1870.

3121 J. Bowden and R. Shaw—Apparatus for felting or planking hat bodies, &c.
3122 J. Bottomley and W. Bottomley—Apparatus for "dewing" woollen or other woven or felted fabrics
3123 M. Burnett—Reducing heat and smoke
3124 W. Buck—Apparatus for locking, &c.
3125 H. S. Bethell—Manufacture of pavements, &c.
3126 A. Dyson—Carding wool, &c.
3127 J. Brooks and T. Cundy—Construction of cramps, &c.
2128 T. Lambert—Pianofortes
2129 R. Sinclair—Apparatus for injecting
3130 H. Bessemer—Propelling projectiles
3131 F. B. Taylor—Drilling, &c.

DATED NOVEMBER 30TH, 1870.

3132 C. Martin and G. O. Mew—Construction of ladders
3133 J. A. Lee and E. Sweetapple—Manufacture of paper
3134 C. W. Siemens—Reducing iron ores
3135 T. Hydes and J. E. Bennett—Construction of furnaces
3136 C. Heirons—Improved alarum
3137 R. Lees—Boilers
3138 W. Hackney—Treating iron ores
3132 H. Larkin and W. White—Production of iron and steel
3140 J. Keighley, R. Shephard and J. Robinson—Looms for weaving
3141 M. Tobin—Boots and shoes, &c.
3142 W. Buck and W. Watkin—Machinery for making bricks
3143 G. Haseltine — Construction of sheet metal elbows, &c.
3144 R. Montgomery — Longitndinally-corrugated beams or rails of steel
3145 J. G. Horsey—Manufactnrs of brnshes, &c,

DATED DECEMBER 1st, 1870.

3146 S. Schofield and A. Schofield—Apparatus for wringing, &c.
3147 R. Boyd—Boilers
3148 T. Wrigley, H. Bruce, C. Dietrich and J. Seitz—Manufacture of half-stuff and paper
3149 P. McIntyre—Shirts
3150 H. L. Gleig—Pianofortss
3151 A. V. Newton—Cutting loaf sugar
3152 W. H. J. Grout—Wheels for velocipedes, &c.
3153 T. Lawrence McCready — Apparatus for giving danger and other signals
3154 A. M. Clark—Fire-arms
3155 J. Clews and F. Clews—Improved top
3156 H. Kesterton—Manufacture of taper tubes and rods
3157 A. N. Wornum—Pianofortes
3158 W. Carter—Production of plain and fancy nets and laces
3159 H. Doulton—Construction of irrigation conduits and channels

DATED DECEMBER 2nd, 1870

3160 T. J. Marshall—Apparatus for washing, &c.
3161 J. Coppard — Constructing portable folding furniture
3162 J. J. Parkes—Gas stoves
3163 J. Weems and W. Weems—Apparatus for heating, &c.
3164 J. R. McVoy—Apparatus for instantly detaching railway carriages
3165 W. R. Lake—Improvements in axles, &c.
3166 S. Bishop and C. Bishop—Improvements in furnaces
3167 F. Hille—Manufacture of deodorizing and disinfecting compounds
3168 J. A. Faulkner and J. H. Stabling—Improvements in window, door, and table fasteners
3169 H. Y. D. Scott—Treatment of sewage
3170 G. Little — Machinery for doubling yarns, &c.
3171 G. Little — Machinery for combing cotton, &c.
3172 I. A. Read—Metallic bedsteads and cots
3173 J. E. Boyce and R. Harrington—umbrellas and parasols

DATED DECEMBER 3RD, 1870.

3174 W. Hargreaves and W. Inglis—Blowing engines
3175 G. Haseltine—Metals from lead and zine
3176 G. Holcroft and W. N. Dack—Improvements in engines
3177 H. B. Barlow — Embroidering machines
3178 J. Farqnharson—Fire-arms
3179 J. Robb—Four-way valve apparatus
3180 A. Lely—Apparatus for cutting chaff
3181 N. Wilson and C. Heugst—Pulping machinery
3182 G. T. Bousfield—Rosin oil
3183 E. T. Hughes—Sewing machines
3184 M. Stell—Spinning, &c.
3185 J. Combe—Winding cops
3186 E. R. Turner—Steam engines
3187 J. Hunter—Blast furnaces
3188 G. Haseltine—Buttons

DATED DECEMBER 5TH, 1870.

3189 W. E. Yates—Flat-irons
3190 P. Kagenbusbh—Metals
3191 J. Johnson, J. Lowe and J. Fowler—Spindles and flyers
3192 H. Jarman and J. Salter—Steering
3193 S. Mallory—Dipping candles
3194 J. H. Johnson—Bleaching
3195 J. H. Johnson—Gratings, &c.
3196 F. J. Bugg—Leather
3197 A. A. Cochrane—Shield

DATED DECEMBER 6TH, 1870.

3198 T. R. Shaw and S. Boardman—Lubricators
3199 A. Bell—Horse-shoes
3200 J. Macintosh—Waterproofing
3201 J. Macintosh—Varnishes and inks
3202 T. Dunn—Obtaining mineral waters
3203 H. A. Dibbin—Signalling
3204 R. Bond and T. N. Charles—Railway chairs
3205 W. N. Hutchinson—Attaching plates or bars to railway rails
3206 J. Howard and E. T. Bousfield — Securing the joints of boilers, &c.
3207 J. Turner—Crank-action
3208 P. Spence—Prussiate of potash
3209 P. Adie and W. Simpson—Lamps
3210 W. Mort—Freezing machines
3211 W. Chamberlain—Railway signals

DATED DECEMBER 7TH, 1870.

3212 E. Kitchin and M. Kitchin—Jiggers
3213 H. Hammond—Mixing soils, &c.
3214 A. M. Clark—Clothing
3215 A. V. Newton—Cartridge-box
3216 T. A. Bickley—Metallic bars
3217 F. J. Howard—Horse-shoes
3217 W. H. Maitland—Carpet linings

DATED DECEMBER 8TH, 1870.

3219 V. Pendred—Traction engines
3220 W. Jackson and G. Wilson—Breakwaters
3221 J. Horner and H. Starkey — Soap-cutting machines
3222 W. T. C. Pratt—Signalling
3223 J. Oldroyd, M. Oldroyd. J. Woodcock and J. Coulter—Dyeing
3224 J. C. Mewburn—Engines
3225 J. C. Mewburn—Ejecting fluids
3226 W. H. Tooth—Fire-arms
3227 W. Parkins, H. Gotto and H. G. Gotto—Wrapper for postal purposes
3221 W. L. Wise—Gas
3229 J. Wright—Closet seats

DATED DECEMBER 9TH, 1870.

3230 E. B. Lockyer—Rolling stock
3231 E. B. Lockyer—Iron ships of war
3232 N. Ager and W. P. Pickering—Signalling on railways
3233 T. Grason—Making carpets, &c.
3234 G. P. Harding—Writing machines
3235 J. Blakey—Boots and shoes
3236 J. Hopkinson—Combined hopper
3237 T. Read—Mowing machines
3238 J. Fletcher—Grinding corn
3239 W. D. Ruck—Paper pulp

DATED DECEMBER 10TH, 1870.

3240 J. Musgrave—Railway signals
3241 J. Boyns—Metallic orss
3242 Lieut. F. Bacon—Fire-arms
3243 J. C. Browne—Combination tool
3244 J. Cooke—Duplicate machines
3245 G. Zanni—Electric telegraph
3246 W. Perkins and G. G. Tandy—Holders

DATED DECEMBER 12TH, 1870.

3247 J. O. Rigby and G. Cussons—Vegetable fibre
3248 J. Harris—Horse-shoes
3249 J. Hosking and J. Morrison—Boilers
3250 J. C. Mewburn—Saccharine matter
3251 G. W. Hick—Bricks
3252 F. O. Karuth—Cigars
3253 J. H. Johnson—Meat
3254 W. D. Ruck—Lamps
3255 C. W. Siemens—Charging receivers

DATED DECEMBER 13TH, 1870.

3256 W. Palliser—Magazines
3257 A. Henry—Blank cartridge
3258 W. W. Gibson—Seeds
3259 J. Kenyon—Nuts on bolts
3260 T. J. Smith—Wire bands
3261 J. J. Coleman—Lubricating oils
3262 A. Ford—Applying moisture
3263 D. Greig and J. Cozney—Carriages
3264 A. W. Gillman and S. Spencer—Reer
3265 J. S. Smyth—Communications
3266 W. R. Lake—Electrical brake

DATED DECEMBER 14th, 1870.

3267 J. E. Lee—Hammer heads
3268 F. L. H. Danchell—Peat
3269 F. L. H. Danchell—Sewage matter
3270 W. H. Hacking—Warping machines
3271 J. C. Clive—Coffins
3272 P. Brannon—Balloons
3273 E. Slack—Sizing, &c.
3274 W. R. Lake—Products of matter
3275 W. Boggett—Applying slate
3276 W. H. Lascelles—Office table

HYDRAULIC PUMP, BY MESSRS. HAYWARD TYLER & Co.

ENGINEERS. LONDON

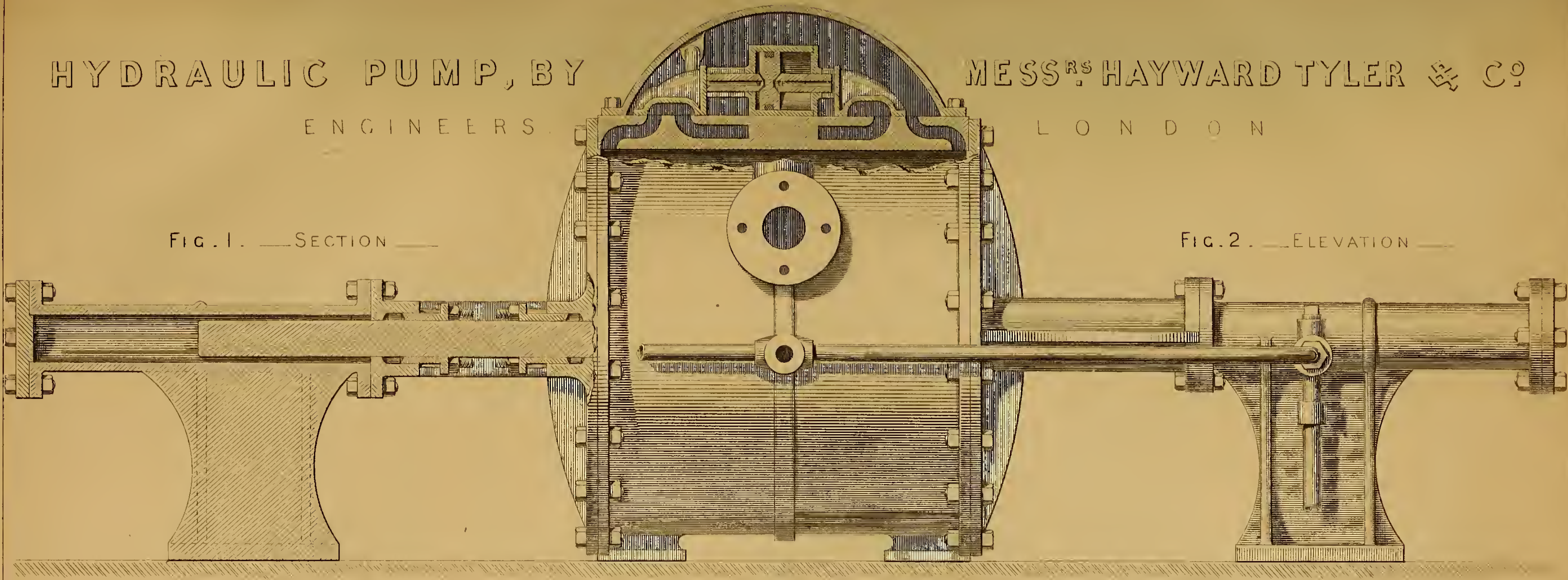


Fig. 1. — Section —

Fig. 2. — Elevation —

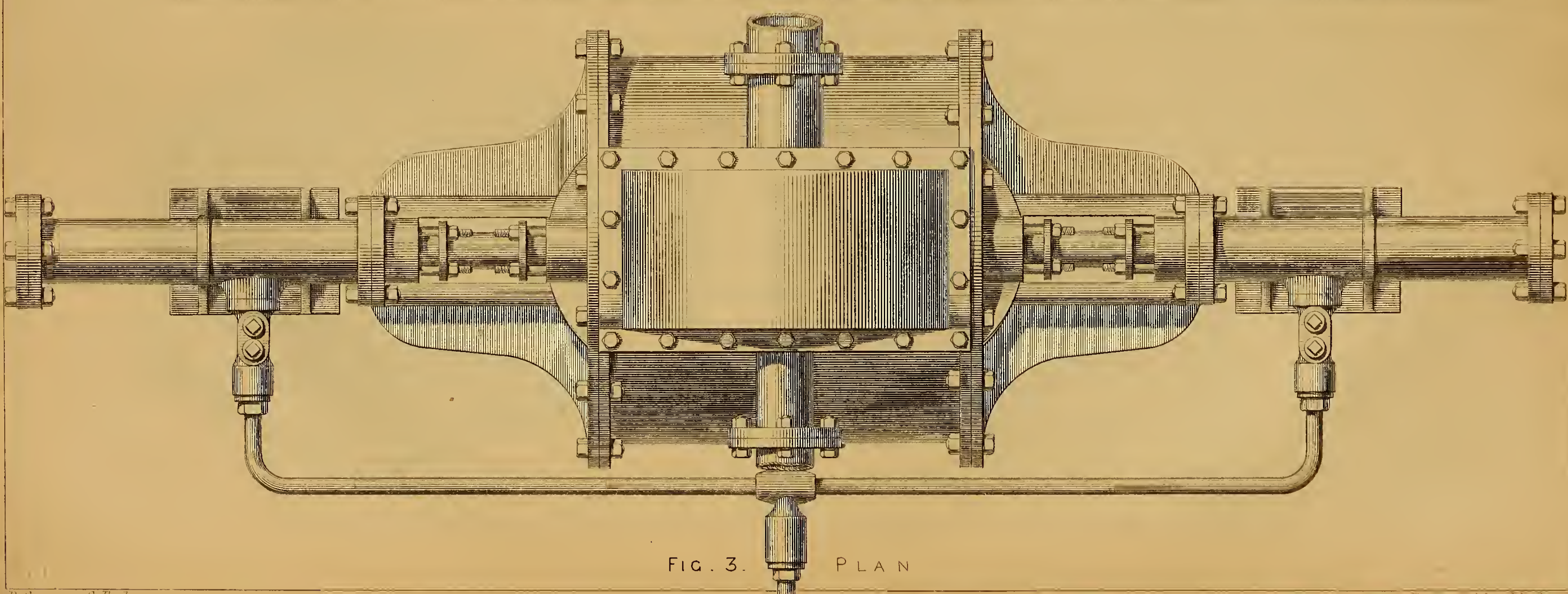


Fig. 3. Plan

P. Soames, C.E. direx

THE ARTIZAN.

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1st FEBRUARY, 1871.

HYDRAULIC PUMP.

By Messrs. Hayward Tyler and Co.

(Illustrated by Plate 370.)

In The Artizan for last November, a Plate and description was given of an arrangement for a seed-oil mill, in which the hydraulic presses were worked by pumps driven from a cross shaft worked by the main steam engine. This arrangement, although almost universal, has the disadvantage of working the pnmp at an invariable speed, and although that is somewhat overcome by the employment of two different sized plungers, it is obvions that such a system only mitigates the defect while it increases the expense. Again it is well-known that for most purposes for which hydraulic presses are employed, when the maximum pressure is attained, it is necessary to continue that pressure for a considerable period. This is nsually done by placing a safety valve on the delivery, and keeping the pumps working. By this method, the desired object is obtained, provided the safety valve is in good order, but at the expense of continuously forcing a qnantity of water through this valve.

In order to obviate these objections, Messrs. Hayward Tyler and Co. have lately designed and erected at Messrs. Prockter and Bevington's works at Bermondsey, a very pretty arrangement of double pump, worked somewhat npon the principle of their well-known "universal" pump, only instead of having the valves in the piston, a supplementary valve chest and piston is nsed. In the former arrangement it was necessary to use a piston longer than the stroke, but by this means a common piston is used, and the cylinder thereby shortened to a corrêsponding extent.

In Plate 370, is shown an elevation, partly in section and a plan of this pump, by which it will be seen that the steam cylinder is in the centre with piston rods working ont at both ends, each of which acts as a plunger for a hydranlic pump. The diameter of the piston of the steam cylinder is so proportioned to that of the piston-rod or plunger of the pumps, that the requisite maximum pressure of water against the plunger shall balance the pressure of steam against the piston. Thus, supposing a hydraulic pressure of 5,000lbs. per square inch was the maximnm pressure desired, and that the steam pressure for working the pump was 50lbs., the area of the steam piston would have to be about 100 times that of the plunger, in other words a 10in. cylinder would be necessary for working an inch ram.

In working a hydraulic press with a pump of this description, the only thing to be done as soon as the press is filled, is to open the steam-cock when the engine, at whatever position of the stroke it may be immediately starts. As the pressure to be overcome is at first very small, the pump works very rapidly, but as this is gradually brought np, to the required maximum, the increased resistance causes the pump to work slower until at last, when that pressure is attained, the pump is brought to a stand. As, however, by means of an arrangement to be hereafter described, there is no dead point in this pump, as soon as the hydraulic pressure from any reason decreases—such for instance, as the extraction of oil from seeds—the pressure of steam in the cylinder causes the pump to start afresh. Thus, it will be seen, that great rapidity is attained jnst at the right time, and afterwards an even pressure is maintained without the intervention of safety-valves and conseqnent waste of power.

In order to explain the means by which the dead point alluded to above, is overcome, the accompanying illustrations of the valve motion are given in Figs. 1, 2 and 3, Fig. 1 being a sectional elevation of the valve, Fig. 2 a plan, and Fig. 3 a cross section of the valve and cylinder.

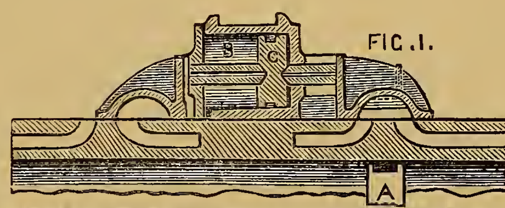


FIG. 1.

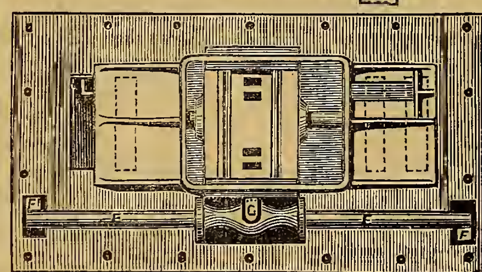


FIG. 2.

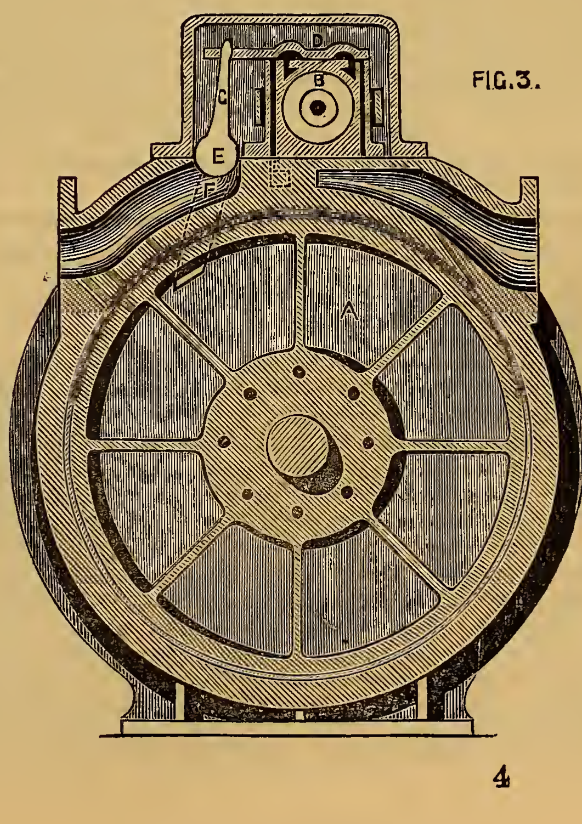


FIG. 3.

The engine is fitted with a steam cylinder and piston A of ordinary construction, with a steam chest attached as usual to the top of it, as shown in Fig. 3. Within the steam chest is a small cylinder B, bolted to the valve face, fitted with a piston having two hollow piston-rods, one at each end, passing through openings in the cylinder covers, which are bored to fit them. The slide of the main cylinder is composed of two slide valves coupled together at the sides. This is dropped over the small steam cylinder B, and the hollow piston rods are so regulated as regards length, that they are a slack fit between the inside ends of it. The small cylinder is provided with a slide valve D, and ports leading to the alternate steam ports of the main cylinder, entering them on the exhaust port side, and forming a part of the slide face. A weigh shaft, E, lies in the steam chest in a direction parallel to its axis, having three arms, F, F^1, G, attached. The middle one G connects with the slide valve D of the small cylinder, the two end ones F, F^1, extending into the main cylinder A, by means of recesses, as shown in Fig. 2, cast for the purpose, the ends being bevelled in the direction of the axis of the cylinder. The action of this arrangement of valve-gear is as follows :—

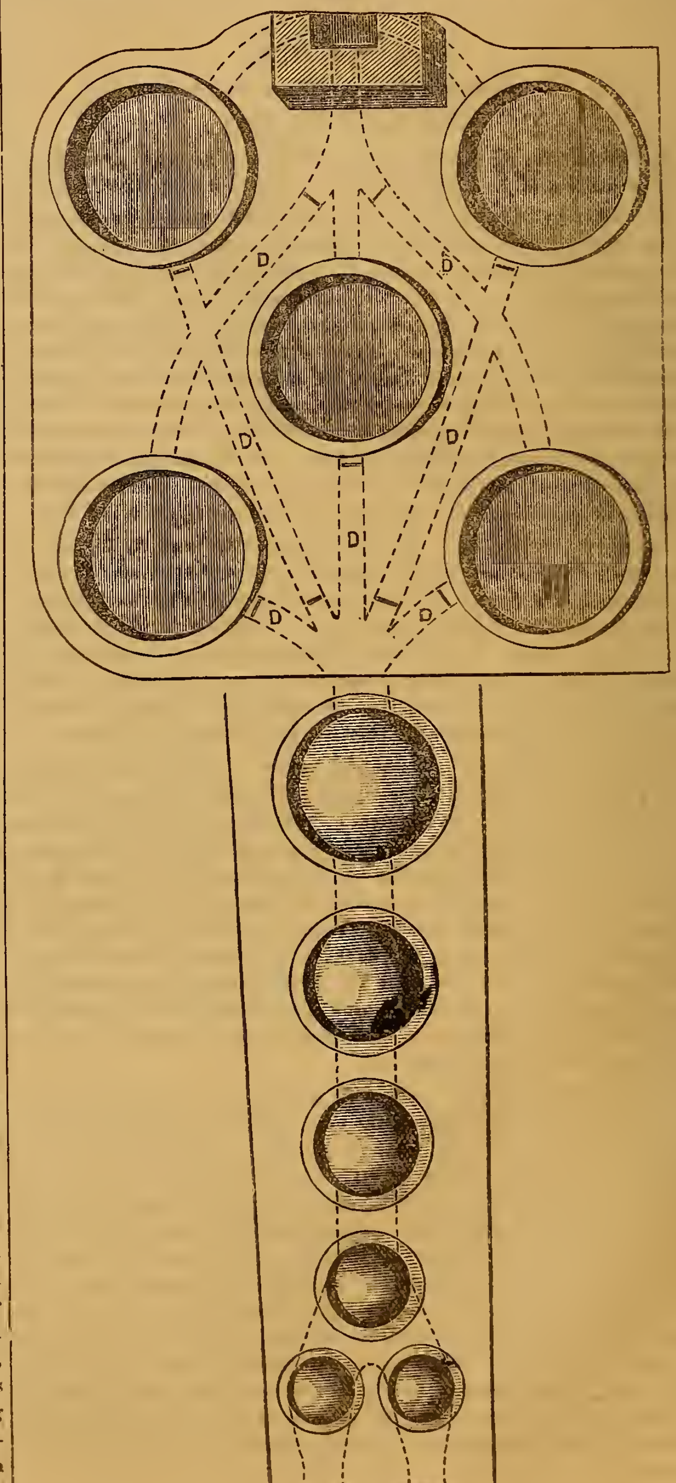
On the piston approaching the end of its stroke, it impinges upon the bevelled surface of the arm F, projecting within the cylinder pressing it back, and thus causing a partial rotation of the weigh shaft E, within the steam chest, and throwing the centre arm G over, thereby altering the position of the slide valve D of the small cylinder B ; the effect of which is to allow the steam of the opposite end to escape into the steam port of the main cylinder at that end at which the piston now is. Now at this position of the piston, the slide valve is exhausting at that end, consequently the steam passes into the main exhaust. The pressure being relieved from one end, the steam on the other side of the small piston moves it over until the hollow piston rod comes into contact with the slide valve, thus closing that end and opening the other to the steam, which continues the stroke and carries the main slide valve with it. As the main slide is thus caused to travel it opens the port of the small cylinder B into the main steam port instead of into the exhaust, when the action of this small port is reversed. The steam will then rush back upon the small piston cushioning it, and leaving that end of the small cylinder charged in readiness for the return stroke, when the same process takes place at the opposite end. Had the exhaust of the small cylinder been taken out into the open air or into the main exhaust direct there would have been no cushion for the small piston. There would also have been no steam to commence the return stroke. By this arrangement no dead point is encountered, the steam being always full on one side or the other of the main piston.

ON THE MANUFACTURE OF SUGAR IN THE COLONIES.

(*Continued from page* 268, *vol.* 4.)

Evaporation.

In The Artizan for December last, while treating upon a few of the various systems of defecation or clarification of the cane-juice, we mentioned that the subsequent processes were more of a mechanical than chemical nature. Although this is undoubtedly the fact, yet a considerable amount of skill, or, at least, of practice, is required to perform successfully the apparently simple process of evaporating the surplus water from the cane-juice in the state in which we then left it. Although in these papers we profess to illustrate only such methods employed in sugar manufacture which are in our opinion the most suitable, yet for the purpose of more clearly illustrating the peculiarities of this portion of the manufacture we give in the accompanying illustration a very usual, but, at the same time, a very inferior method of effecting this purpose. Another reason might also be given for illustrating this method, viz., that it is not only the most universal arrangement in practical use in the colonies but also the oldest. The system appears to be as old as the manufacture of sugar, at least as old as when this manufacture was first introduced into the various colonies. It is apparently a slightly improved copy of the Chinese method, where three, four, or five evaporating pans are placed over one fire, this fire being contained in a rectangular furnace about twelve or fourteen feet square by eight feet high, and composed of logs of wood three or four feet long, and reminding one, when it is in " full swing," of the celebrated furnace of Nebuchadnezza. In the annexed illustration of the colonial system, it will be seen that the pans are placed longitudinally, and that they vary



in size. By this means the smallest (or as is here shown the two smallest) is placed directly over the furnace, and the others in line along the flue. The variation in the size of the pans was considered necessary in order that each of them should contain the same amount of saccharine matter. Thus the largest pan, or, as it is usually termed, the "grand copper," is for the reception of the clarified but unevaporated cane-juice, while the smaller pan next adjoining it is supposed to be able to hold the contents of the grand copper after a portion of the water has been evaporated. As a somewhat larger proportion of water is evaporated in the second copper, the dimensions of the third copper is proportionately less, and so on until the liquor, now in a high state of concentration, finds its way, or, rather, is ladled, into the smallest of all, which is usually called the teache." The reason for proportioning the size of these evaporating vessels so that each should be presumed to hold the same amount of sugar is difficult to understand, but as far as we can judge it arose from a peculiar species of superstition, viz., that precisely the same embryo crystals would pass regularly from one stage to another of concentration until they were finally "skipped" into the cooler. The later introduction of two teaches at the end of the battery, as shown in the accompanying engraving, must, we think, have dispelled this illusion, as in most cases where it has been adopted each of these coppers are generally of the same size as the original single teache.

The process of concentration of the cane-juice by means of a set of coppers according to this system is very simple, but very imperfect. When a sufficient quantity of cane-juice is brought down from the clarifiers the head boiler-man "calls fire," whereupon, as soon as possible, an intense fire of burning cane trash is brought to play upon the smallest pan or teache, and is led by means of an undulating flue beneath the rest of the coppers. It is most essential that the process of evaporation when once commenced should be carried on vigorously and unceasingly, as the less time to which it is exposed to the air the better will be the sample of sugar. In order to effect this object the flues are usually made of a considerably greater area than that allowed for steam boilers, and as a natural consequence an enormous percentage of the heat from the flaming "cane trash" or "megass" passes beyond the range of the coppers. This waste heat is generally made available for the purpose of heating the clarifiers, and in the accompanying engraving a system that prevails in the West Indies for that purpose is illustrated. It will be seen that the heated products of combustion, after passing under the range of evaporating pans are, by means of a regular system of flues, shown in dotted lines and dampers (marked D) caused to pass under any one of the clarifiers that require to be heated before reaching the chimney. By this arrangement an additional portion of the heat is utilised, but still the waste is something enormous.

In making sugar by means of this primitive battery there is, as we have already mentioned, but little skill required; but, on the other hand, constant attention and incessant labour is of the utmost importance. Thus, a continuous fierce boil must be kept up, which, of course, with the peculiar material used for fuel, requires unremitting attention. The scum, also, which forms upon the top of the froth thus formed, has to be constantly removed and deposited into the gutter running alongside the battery, and thence to the still house. These duties are, however, merely mechanical, and the only skill required is for judging when the juice is sufficiently concentrated for skipping into the coolers. Before touching upon this point, however, a few remarks upon the evaporating process may be useful. The cane-juice, if properly clarified, should, when boiling, be of a delicate straw colour, the colour being more distinct as it is concentrated; but this test cannot always be depended upon, as the colour not only varies with the age of the cane—the older the cane, as a rule, giving the paler juice—but also with the soil upon which it is grown. When much lime is used in the process of clarification the colour of the boiling liquid is considerably darkened, and when, in addition to this, a peculiar burnt smell is perceptible, there has been either too much lime used, or the canes have been allowed to get sour in the yard before passing through the mill. Sometimes an insufficient quantity of lime has been used in the clarifier, and in that case the juice when boiling gives off a somewhat acid scent. This fault, if fault it be, is easily remedied by the addition of milk of lime in the grand copper until the litmus test is satisfied. We have hesitated to pronounce this to be a fault, as we believe that a great deal more sugar is spoilt by too much, than by too little lime; and, therefore, consider that insufficiency of lime is at least an error on the right side.

The proper time for "skipping" the juice when boiled, under the arrangement above described, is usually controlled by the judgment of the head boiler-man, who has his own peculiar method of judging the maturity of the liquor. We are of course aware that a great deal has been written and re-written about testing the state of the liquor in the teache by means of the appearance and behaviour of a small quantity taken out for that purpose; but as the same, or almost the same, appearance will be assumed by two samples varying greatly in the amount of water they contain, if only the temperature is also varied, a correct judgment by the sight cannot be properly described, nor can it be learnt except by considerable experience. The only scientific test by which the degree of concentration of cane-juice when evaporated in an open pan can be ascertained is by the thermometer. This not only forms a very accurate test, but is a check upon any excess of evaporation, and consequent over colouring of the sugar. The change in the colour observable in a teache full of sugar as it approaches concentration is very distinct; in fact, the process of destruction as the heat rises to the point necessary for complete evaporation under this barbarous process becomes sufficiently rapid, one would think, to demonstrate to any planter that he was spoiling the very material for which he had laboured.

As sugar is soluble in half its weight of cold water, it is evident that the percentage of water left unevaporated in the liquor when it is skipped, will form three times that percentage of molasses. Thus supposing 10 per cent. of water is contained in the liquor, that quantity when cold will dissolve 20 per cent. of sugar, forming molasses, and leaving 70 per cent. of crystallized sugar. The heat required to concentrate the liquor even up to this point, is so great, (about 242 deg. Fahrenheit), that the colour of the sugar is excessively darkened. In practice, it is found that it is better not to exceed a temperature of 240 deg., when the yield of sugar ought to be about 60 per cent. of the amount run into the coolers.

(To be Continued.)

TRAMWAYS IN LONDON.

At the meeting of the Metropolitan Board of Works on the 13th ult. a report was presented from the Parliamentary Committee on the tramway schemes proposed in the metropolis. The report stated that the committee had not felt themselves at liberty, as they desired, to go into the general question as to the expediency of laying down tramways, as that had already received the sanction of Parliament, and the Act of last Session embraced two alternatives, either of which may be adopted by the Board. They may either undertake themselves the construction of tramways throughout the metropolis, leasing the lines so constructed to other bodies or companies, for the purpose of being worked by the latter, or they may authorise the laying down of tramways by other bodies in the first instance. The committee had considered both these courses. The advantages offered by the first alternative—viz., the construction of tramways by the Board, appear to be twofold:—1, The securing from an expenditure of capital such a return as should suffice, not only to pay the interest on the amount expended, but to afford a surplus, by means of which the Board might be able to effect improvements in the metropolis, or to relieve the ratepayers of a portion of their present burdens; and, 2, the laying down of tramways upon a more general and comprehensive plan than would be adopted by a number of companies competing one against another. In the first place, there would probably be a strong objection on the part of many to the Board expending the public money on a work of this kind, partaking as it would, to some extent, of the character of a commercial enterprise. It should be borne in mind that the Act contains provisions empowering

the Board at the end of 21 years, and, nnder certain circumstances, earlier, to purchase any tramway, paying simply the value of the materials and works (exclusive of any allowance for past or futnre profits of the undertaking, or any compensation for compulsory sale, or other consideration whatever). It will thus be in the power of the Board at the end of the period specified, or of any subsequent seven years, to acquire possession of any tramway on the most favourable terms, and they will then have obtained sufficient experience to enable them to decide as to the expediency of purchasing. As regards the second advantage above-mentioned as likely to be derived from the construction of tramways by the Board,—viz., the adoption of a more general and comprehensive plan than would otherwise be the case, it appears to your committee that this object can be obtained, though perhaps not quite to the same extent, nnder the other alternative. They are fully sensible of its importance, and, indeed, recognize the fact that it was mainly with this object that the promoters of tramways were required to have the consent of this Board before they could obtain a provisional order. The adoption of some definite plan is the more necessary in the infancy of metropolitan tramways, becanse when once lines have been laid down to any extent it will be difficult, perhaps impossible, to remedy any want of arrangement and design which may exist. It is, therefore, not without anxiety and a strong sense of responsibility that your committee have considered the numerous and extensive schemes now before the Board. One of the leading ideas by which they have been guided is that tramways should, as far as possible, be confined, except in suburban districts, to thoroughfares in which omnibuses now run. There will necessarily be exceptions to this rule, but, generally speaking, it appears to them that the existence of an omnibus traffic in any particnlar line is evidence of a necessity of a regular meaus of locomotion there, and, on the other hand, where there is no omnibus traffic it may be generally assumed that tramways are not at present required. Having at some length referred to the inexpediency of having tramways in side streets, or to have more than a double line in any thoroughfare, the report thus proceeds:—"In every case, therefore, in which more than one company apply for a particnlar line, your committee have carefully considered the qnestion by which of the companies they should recommend the Board to sanction the construction of the tramway; and they have acted upon the opinion that it would be for the public convenience that every main line from the centre to the outskirts should be as far as possible in the hands of one company. It appears to your committee that Parliament in passing a general Act to facilitate the construction of tramways did so clearly with the intention that in fnture all applications for power to construct tramways should be made under, and governed by the provisions of that Act. The principal object of a general Act was to secure uniformity in the conditions under which tramways should be constructed; and if promoters of schemes were to obtain a separate Act in each case, there would probably be in each Act different provisions. Your committee are, therefore, of opinion that representations should be made to the Board of Trade with a view to their opposing those schemes which are not proceeded with in the way prescribed by the general Act, and in which it is sought to obtain Parliamentary powers independently. With regard to the form of consent to be given, it is suggested that the Board should give a general consent to the lines of which they approve, reserving to themselves full power to propose such modifications in the terms of the provisional order, and such conditions as may be considered advisable in the interests of the various districts and of the public generally. Your committee recommend that the matter be referred back to them, with instructions to prepare a series of reservations to be attached to the consent to be forwarded to the Board of Trade."

The following are the recommendations of the committee:—

"1. That the consent of the Board be given to the construction of a line of tramway commencing at Shepherd's Bush and proceeding along Uxbridge-road, Oxford-street, and Holborn, to the city boundary at Holborn-bars; 2. A line of tramway commencing at the Edgware-road Railway Station on the Hampstead and City Junction Railway, and proceeding southward along Edgware-road to the Marble Arch; 3. A line of tramway commencing at the junction of Marylebone-road with Edgware-road, and proceeding eastward along Marylebone-road, Enston-road, and Pentonville-road, to the Angel Inn; 4. A line of tramway commencing at the Mother Red Cap publichonse, and proceeding by one line along Park-street to the York and Albany pnblichouse, and by another along High-street, Camden-town, Wellington-street, and Glocester-street, to the York and Albany; thence along Albany-street to the junction of the last-mentioned street with Marylebone-road; 5. A line of tramway in continuation of the anthorised line in Hampstead-road, to proceed along Tottenham-court-road to Oxford-street; 6. A line of tramway commencing at the junction of Pentonville-road with King's-cross-road, near the King's-cross Railway Station, and proceeding along King's-cross-road and Farringdon-road to the boundary of the city; 7. A line of tramway commencing at the junction of Camden-road with Holloway-road, and thence proceeding along the entire length of Caledonian-road to the King's-cross Railway Station; 8. A line of tramway commencing at the West London Junction Railway Station in Hammersmith-road, and proceeding along Kensington-road, Knightsbridge-road, and Piccadilly, to the Regent-circus; 9. A line of tramway commencing at the Regent-circus in Piccadilly, and thence proceeding along the Haymarket, Cockspur-street, Charing-cross, Whitehall-place, and the Victoria Embankment, to form a connection with the proposed line over Westminster-bridge; 10. A line of tramway commencing by a junction with the authorised line in Blackfriars-road at the corner of Southwark-street, and passing along Southwark-street to a junction with the proposed line in Wellington-street, Southwark; 11. A line of tramway commencing at the Swiss Cottage, and proceeding in a sonth-easterly direction along Finchley-road and Wellington-road to Marylebone-road; 12. A line of tramway in Edgware-road from the boundary of the metropolitan area to the Edgware-road station of the Hampstead and City Junction Railway, there to form a connection with the proposed line of the London Street Tramways Company; 13. A line of tramway in Uxbridge-road from the bonndary of the metropolitan area to Shepherd's Bush, to form a continuation of the proposed line of the London Street Tramways Company; 14. A line of tramway from the western boundary of the parish of Hammersmith, and proceeding eastward along the Great Western-road and Hammersmith-road to the West London Junction Railway Station, to form a connection with the proposed line of the London Street Tramways Company; 15. A line of tramway commencing at the western boundary of the parish of Hammersmith, running thence northward along the New-road, thence eastward along Goldhawke-road to Shepherd's Bush, forming a connection with the proposed line of the London Street Tramways Company; 16. A line of tramway commencing at Putney-bridge and proceeding in a north-easterly direction along Fulham-road to Pelham-crescent; 17. A line of tramway commencing at Cremorne-gardens, Chelsea, and thence proceeding along King's-road to Sloane-square, and thence along Sloane-street to Knightsbridge, forming a junction wlth the proposed line of the London Street Tramways Company; 18. A line of tramway commencing at the Angel Inn, and proceeding along Goswell-road and Goswell-street to the city boundary; 19. A line of tramway commencing at the junction of Goswell-road with Old-street, and proceeding along Old-street, Old-street-road, and Hackney-road, as far as Grove-road; 20. A line of tramway commencing at the city boundary in Bishopsgate-street, and proceeding northwards along Bishopsgate-street, Kingsland-road, Stoke Newington-road, to the bonndary of the metropolitan area at Stamford-hill; 21. A line of tramway commencing at Stamford-hill and proceeding southwards along Upper Clapton-road, Lower Clapton-road, Church-street, Mare-street, Cambridge Heath, and Cambridge-road to Mile-end-road, forming a junction with the existing line in that road; 22. A line of tramway from the boundary of the metropolitan area at Finsbury-park, passing throngh Green-lanes, Newington-green, Mildmay-park, Sonthgate-road, Bridport-place, Mintern-street, New North-road, and East-road, to a junction with the authorised line in the City-road; 23. A line of tramway commencing at Victoria-park, and proceeding sonth along Grove-road and Burdett-road to a junction with the proposed line in East India Dock-road; 24. A line of tramway commencing by a jnnction with the anthorised line in Whitechapel, High-street, and proceeding along Commercial-road and East India Dock-road to the East India Docks; 25. A line commencing by a jnnction with the proposed tramway in Mare-street, Hackney, thence passing along Richmond-road, Park-road, Dalston-lane, Ball's-pond-road, and Essex-road, and terminating by a junction with the authorised line near Islington-green; 26. A line of tramway commencing by a junction with the existing line at Kennington-park, and proceeding along Kennington-park-road, Newington-causeway, and the Borough High-street, to London-bridge; 27. A line of tramway commencing at the jnnction of Southwark-bridge-road with Newington-causeway, and thence proceeding along Southwark-bridge-road and Bridge-street, to Southwark-bridge; 28. A line of tramway commencing at a junction with the anthorised line in Victoria-street, and thence proceeding along Victoria-street and the Broad Sanctnary and over Westminster-bridge, to a junction with the existing line in the Westminster-road; 29. A line of tramway commencing in Victoria-road, near the south-east corner of Battersea-park, and thence proceeding along Queen's-road, thence along Wandsworth-road, Lambeth High-street, Albert Embankment, and Palace-road, to Westminster-road, there forming a junction with the existing line; 30. A line of tramway commencing by a junction with the anthorised line near the Obelisk in St. George's-circus, and proceeding along Waterloo-road, and over Waterloo-bridge to the Strand; 31. A line of tramway commencing by a junction with the authorised line near the Bricklayers' Arms station, and proceeding along Dover-street to a junction with the proposed line in the Borough High-street."

IRON SHIPBUILDING.

Tolerably accurate returns have been published of iron vessels built on the Tyne and Wear in 1870. The total number of iron vessels of all kinds built on the Tyne in 1870 is 83: of these two are war ships, 55 iron screw steamers, 5 iron paddle steamers, 10 iron tug steamers, and 1 ferry boat. The largest vessels launched during the year on the Tyne were the ironclad frigates *Swiftsure* and *Triumph*, each 3,892 tons, built by Messrs. Palmer and Co. (limited). The largest vessels for commercial purposes were the *Wisconsin* and the *Wyoming*, each 3,336 tons, also built by Messrs. Palmer and Co., and intended for the Liverpool and New York trade. Messrs. C. Mitchell and Co., of Low Walker, launched 31 vessels of a total tonnage of 30,764; Messrs. Palmer and Co., Jarrow, 19 vessels, of a total tonnage of 29,349; Messrs. Redhead and Softley, South Shields, 8 iron ships, and several wooden tugs, the whole of an aggregate of 5,444 tons; Messrs. J. Wigham, Richardson and Co., Low Walker, launched 6 iron vessels, one the *Expresso*, an Italian Transatlantic mail packet of 2,100 tons, and the aggregate of the whole 8,465 tons; Messrs. Schlesinger, Davis and Co., Wallsend, 6 iron vessels, of an aggregate of 5,484 tons; Messrs. T. and W. Smith, North Shields, seven vessels of the total tonnage of 6,290. In addition to the above, a large firm, Messrs. Lesslie and Co., of Hebbum, has made no return; but they have launched a very considerable number of first-class iron steamers, both screws and paddles, during the year. Twenty-one iron ships are reported as having been built on the Wear in 1870; but the returns are rather imperfect. The most remarkable circumstance in connection with the iron steam shipbuilding trade of 1870 in the North is the extraordinary increase in the number of steamers that have been built for local owners. The vessels are mostly held by partnerships, each share being of the value of between £200 and £300. North Shields, which had scarcely a ton of iron steam shipping five years ago, will have steam shipping property worth a million sterling, it is anticipated, by the end of 1871. There has been a very great increase in the number of iron steamers owned by Newcastle in 1870; and Sunderland and South Shields are going extensively into iron steam shipping property. If the trade developes at the rate it has done during the past year, sailing ships on the Northern rivers in ten years' time will be as rare as stage coaches in the streets of London. The steam shipping of the North did well in 1870. Some of the steamers returned as much as 40 per cent. to their owners; and very few of the new vessels made less than 25 per cent.

ON THE MATHEMATICAL THEORY OF COMBINED STREAMS.

By W. J. MACQUORN RANKINE, C.E., LL.D., F.R.SS., London and Edinburgh.

1. OBJECT OF THIS INVESTIGATION.

The principles of the action of combined streams were to a certain extent investigated by Venturi, and stated in his essay "Sur la Communication latérale du Mouvement dans les Fluides" (Paris 1798). The principle of the conservation of momentum, so far as I know, was first explicitly applied to combined streams by Mr. William Froude, F.R.S., in a paper on Giffard's Injector, read to the British Association at Oxford, in 1860, and published in the transactions of the section, p. 211. Various other authors have treated the same problem by different methods, based virtually on the same principle. A very complete and precise investigation of the theory of combined streams, in every case in which two streams only are combined, is contained in Professor Zeuner's treatise "Das Locomotivenblasrohr" (Zürich, 1863). The theoretical conclusions are tested by comparison with experiment, and applied to practical questions, especially those relating to the apparatus from which the treatise takes its name. The object of the present investigation is to apply similar principles to the combination of any number of streams; and the demonstration of the fundamental dynamic equation differs from that given by Zeuner in method, though not in principle, being effected at one operation by the direct application of the principle of the equality of impulse and momentum, instead of by the consideration of the loss of energy that takes place during the combination of the streams.

2. TERMS AND NOTATION USED, AND SUPPOSITIONS MADE.

The several streams which are combined will be called before their junction, the component streams; the stream formed by their combination will be called the resultant stream. The passages through which the component and resultant streams flow will be called respectively the supply tubes and the discharge tube. The combination of the streams will be supposed to take place in a short cylindrical chamber, with its axis parallel to the direction of flow, which will be called the junction chamber.

At one end of the junction chamber are the outlets of the supply tubes, which will be called the nozzles; at the other end, the inlet of the discharge tube, which will be called the throat. It will be supposed, further, that the supply tubes are so formed as to direct the component streams at the nozzles, so that they shall all flow sensibly parallel to each other and to the resultant stream. The principal symbols used are as follows: for any one of the component streams:—

a, area of nozzle;
v, velocity of flow at nozzle;
s_0, bulkiness, or reciprocal of density at nozzle.

The several component streams may be distinguished from each other, when required, by suffixes; as 1, 2 3, &c.

For the resultant stream:

A, area of throat;
V, velocity of flow at throat;
S_0, bulkiness, or reciprocal of density at throat.

Intensities of pressure, (in absolute units) on the unit of area:

p_0, at the nozzle end of junction chamber;
P_0, at the throat.

(These may be converted into units of weight on the unit of area, by dividing by g.)

The flow of each stream is supposed to be steady. The fluids may be either liquid, vaporous, gaseous, or mixed.

3. EQUATION OF CONTINUITY.

The mass of fluid that enters the junction chamber through a given nozzle in a unit of time is $\frac{av}{s_0}$. The mass discharged in the same time at the throat is $\frac{AV}{S_0}$. The flow being steady, the following equation must at every instant be fulfilled:

$$\frac{AV}{S_0} = \Sigma . \frac{av}{s_0}. \quad \ldots \ldots \ldots \quad (1)$$

If S_0, and the several values of s_0 are given, that equation gives the velocity of the resultant stream in terms of those of the component streams; viz.

$$V = \frac{S_0}{A} . \Sigma . \frac{av}{s_0}. \quad \ldots \ldots \ldots \quad (1\text{ A})$$

If all the fluids are liquids, each of sensibly invariable bulkiness, we have also $AV = \Sigma . av$; that is, the volume of flow of the resultant stream is equal to the aggregate of the volumes of flow of the component streams; but if any or all of the streams are vaporous or gaseous, the values of s_0 will depend upon that of p_0, and the value of S_0 upon that of P_0, and upon the changes of bulkiness of the fluids which may take place in the junction chamber, through change of temperature, change of condition, or chemical action.

In any case S_0 may be regarded as a given function of P_0, and of the mutual proportions of the several values of $\frac{av}{s_0}$; in other words, of the ingredients in the resultant stream.

4. DYNAMICAL EQUATION.

The aggregate momentum of the mass of fluid that enters the junction chamber through the nozzles in a unit of time is $\Sigma . \frac{av^2}{s_0}$. The momentum of the equal mass which leaves the junction chamber through the throat in the same time is $\frac{AV^2}{S_0}$.

The forward impulse exerted in a unit of time upon the mass of fluid in the junction chamber by the pressure at the nozzle end of the chamber is p_0A. The backward impulse exerted in the same time on the same mass by the pressure at the throat end of the chamber is P_0A. By the second law of motion, the difference between those impulses is equal to the change of momentum produced; that is to say,

$$A\,(P_0 - p_0) = \Sigma \frac{av^2}{s_0} - \frac{AV^2}{S_0} = \Sigma \left\{ \frac{av}{s_0}(v - V) \right\}; \quad . . \quad (2)$$

or dividing both sides by A,

$$P_0 - p_0 = \Sigma \frac{av^2}{As_0} - \frac{V^2}{S_0} = \Sigma \left\{ \frac{av}{As_0}(v - V) \right\}; \quad . . \quad (2\text{A})$$

And this is the general dynamical equation of the combination of any number of streams of any fluids.

If the preceding equation, as applied to a combination of two streams only, be compared with the equation not numbered, which immediately precedes equation 60 in Zeuner's treatise, it will be seen that they are virtually identical, although different in form, and demonstrated by different methods.

5. Loss of Energy at Junction.

If a given mass of any fluid at the bnlkiness s and pressure p is contained in a reservoir, from which it is capable of being expelled by the inward motion of a piston loaded with an external force equivalent to the pressure, it is known that the poteutial energy of the mass of flnid, and of the piston relatively to a point at the level of the centre of mass of the fluid, is expressed by multiplying the mass by $\int_0^p sdp$, the relation between s and p being that which is called *adiabatic*; that is to say, such that no heat is received or given out by the fluid. Hence the loss of energy in the junction chamber in each unit of time is giveu by the following expression:—

$$\Sigma \left\{ \frac{av}{s_0} \left(\frac{v^2}{2} + \int_0^{p_0} sdp \right) \right\} - \frac{AV}{S_0} \left(\frac{V^2}{2} + \int_0^{P_0} SdP \right), \quad . \quad . \quad . \quad . \quad (3)$$

of which the first, or positive term, denotes the aggregate energy, actual and potential, of the component streams as they enter the junction chamber; and the second, or negative term expresses the total energy, actual and potential, of the resultant stream as it leaves that chamber. That lost energy takes the form partly of visible eddies and partly of invisible molecular motions—that is, of heat.

The integral expressing the aggregate potential energy of the component streams may be put in the following form:—

$$\int_0^{p_0} \left(\Sigma . \frac{avs}{s_0} \right) dp \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3A)$$

If no change of total bulkiness arises from the mixture of the component streams, the volnme occupied by a given mass of the mixture is simply the sum of the volumes of its ingredients; so that we have

$$\frac{AVS}{S_0} = \Sigma \frac{avs}{s^0}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3B)$$

and the expression for the loss of energy becomes

$$\Sigma . \frac{av^3}{2s_0} - \frac{AV^3}{2S_0} - \frac{AV}{S_0} \int_{p_0}^{P_0} SdP \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3C)$$

When the fluids are all liquids, whose compressibility may be neglected, we have $\int_{p_0}^{P_0} SdP = S_0 (P_0 - p_0)$; and substituting for the difference of pressures its value, according to equation (2), the following expression is found for the loss of energy at the junction,

$$\Sigma . \left\{ \frac{av}{s_0} . \frac{(v - V)^2}{2} \right\}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3D)$$

that is to say, in the case of liquids all the energy due to the several velocities $(v - V)$ of the component streams relatively to the resultant stream is lost.

When the expression (3D) is rednced to a single term, it becomes the well-known value of the loss of energy of a single stream of liquid at a sudden enlargement in a tube.

6. Efficiency of Combined Streams.

The efficiency of a set of combined streams may be defined as the fraction expressing the ratio borne by the total energy of the resultant stream after the combination to the aggregate energy of the component streams before the combination. It is expressed as follows:—

$$\frac{\frac{AV}{S_0} \left\{ \frac{V^2}{2} + \int_{p_0}^{P_0} SdP \right\}}{\Sigma \left\{ \frac{av}{s_0} \left(\frac{v^2}{2} + \int_0^{p_0} sdp \right) \right\}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

7. General Problem of Combined Streams.

In most cases the problem of combined streams takes one or other of the two following forms. In each of the two forms the areas of the nozzles a_1, a_2, &c. are given, and also the area of the throat, A.

First Form.

The quantities given, besides the before-mentioned areas, are the pressure at the nozzles, p_0, and the velocities of the component streams, v_1, &c. The functional values giveu are those of $s_{0,1}$, $s_{0,2}$, &c., in terms of p_0, and of S_0 in terms of P_0, $\frac{a_1 v_1}{s_{0,1}}$, $\frac{a_2 v_2}{s_{0,2}}$, &c. Those functional values are to be substituted in the equations (1) and (2); and the solution of these equations will give the numerical values of V and of P_0. In the case of liquids of sensibly constant bulkiness, $s_{0,1}$, &c., and S_0 are quantities sensibly independant of p_0 and P_0; and then equations (1) and (2) can be separately solved without elimination, giving respectively V and P_0.

Second Form.

Each of the component streams flows throngh a passage whose factor of resistance, f, is given, from a separate reservoir in which the pressure p and the elevation z of the surface above the junction chamber are given. The resultant stream flows throngh a passage whose factor of resistance, F, is given, into a reservoir in which the pressnre P and the elevatiou Z of the surface above the junction chamber are given. These, together with the areas A, a_1, a_2, &c., are the quantities given. The functional values given are those of the bnlkiness, $s_{0,1}$, $s_{0,2}$, &c., and S_0, as before; also the following valnes of the velocities, according to well-known principles in hydrodynamics; for any component stream,

$$v = \sqrt{\left\{ \frac{2gz + 2\int_{p_0}^{p} sdp}{1 + f} \right\}}; \quad . \quad . \quad . \quad . \quad . \quad (5)$$

and for the resultant stream,

$$V = \sqrt{\left\{ \frac{2gZ + 2\int_{P_0}^{P} SdP}{1 + F} \right\}}; \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The fnnctional values given are to be snbstituted in equations (1) and (2), whose solution will then give the numerical values of p_0 and P_0; and from these and the other data the numerical values of v, &c., and of V may be calculated.

SOCIETY OF ARTS.

ON A METHOD OF LIGHTING TOWNS, FACTORIES, OR PRIVATE HOUSES, BY MEANS OF VEGETABLE OR MINERAL OILS.

By A. M. Silber, Esq.

We are all familiar with gas-light. It meets our sight wherever we turn, on passing any evening through the busy thoroughfares of populons London. Accustomed as we are to the sight of the brightly illuminated shops and streets, we are scarcely able to realise to ourselves how people fared before the introduction of coal-gas; and yet it is barely 60 years since gas was first thought of as a general illuminant, and in this comparatively short time it has almost entirely superseded—at all events iu our large towns—the sources of light known at the beginning of this century, viz., vegetable and animal oils, and fats of various origin, which, for centuries past, formed the exclusive illuminating material of rich and poor.

The eye is occasionally attracted in our business streets by brilliant white lights, displayed in shop windows, burning from lamps of novel construction, which strike the Londoner, accnstomed as he is to gas-light, as a vast improvement upon the latter. These are the so-called paraffin lights. Who has not stopped for a moment to mnse over the cheerful sight, and has gone his way saying to himself, "This is really a pleasant light; will it ever take the place of gas-light?" In many a humble dwelling in this conntry, and more so in other countries—in Norway, Sweden, Denmark, Germany, Russia, America, aud others—we meet now with the same bright light. The paraffin lamp has in fact pushed aside the old dips, candles and oil-lamps; and the long winter nights of onr northern latitudes have been rendered more cheerful since the introduction of these cheap lights. It is well known that the consumption of paraffin and petroleum oil has increased immensely iu this and other countries during the last eight or ten years, and that the lamps constructed for the combustion of these mineral oils have now found their way into some of the most out-of-the-way places of country districts. When we remember how slowly people familiarised themselves with gas, and how many misgivings about its practical employment as a sonrce of light had to be overcome, it is astonishing how rapidly this new illuminant has come into use. Why are these lights found more frequently in country districts than in towns—more often in the cottage than in the honses of the well-to-do people? We need not go very far to answer

this question. It is on account of their cheapness, and the better light which they prodnce.

There are many people who strongly object to gas, even in these days of almost general consnmption of this lighting material, and many who object more vehemently to the use of mineral oils. Both gas and mineral oils are possessed of a somewhat unsavoury odour; both explode under favourable conditions, *i.e.*, when mixed with air, and when a light is brought into contact with the explosive mixture. But, then, gas can be consumed from properly-constructed burners without giving any smell, and mineral oils, when burned from suitable lamps, burn likewise with little or no odour. Petroleum oil has got into bad repute with people on account of the many shocking accidents by fire, arising from the upsetting of lamps, and the unscrupulous retailing of oils which inflame at low temperatures when they are brought near a light.

If I can show this evening that I have overcome, for the most part, these drawbacks to the use of mineral oils, by employing specially-constructed lamps, and by a perfectly safe and novel mode of conveying the oil to the lamp and wick, you will, I trnst, patiently forbear with me if I do not place the snbject before you as well as its paramonnt importance deserves.

How to Convey and Distribute Oils.

It occurred to me that oils might be distributed like water over our houses, by availing ourselves of the law which applies to all fluids, viz., that they flow till they find their level or equilibrium, and that, by providing a small oil-tank in the upper part of the house, with pipes conveying the oil to the lower parts, any liquid illuminating material might be distributed with the same facility as water is now distribnted over most modern-built houses.

In the place of plain taps, I regnlate the flow of the oil by employing on each floor a little cistern or cisterns, provided with a well-constructed little tap, regulated by a ball-cock or self-acting float, and throngh which the oil must pass on its way to the lights. It is obvious that the lights must be, as nearly as possible, on a level with the distribnting cistern, and that the wicks of the bnrners which dip into the oil must be adjnsted at such a height that they suck up the oil freely, without, however, causing any overflow; in other words, that the oil at the top of the wick is in a state of perfect equilibrinm with the oil in the distributing cistern, though the level need not be absolutely the same, owing to the slight friction in the conveying-pipes and the snction exerted by the cotton wick. When the lamp is lighted, the oil must, on the principle of the ball-cock movement, be supplied to the wick as fast as it is consumed, and with the most marvellous regularity. The light itself, in fact, is made to regulate automatically its own supply of oil. Having thus explained, in the briefest possible manner, the principle which guided me in the distribution of the oil to the lights, I will next proceed to explain to you in detail how this may be done practically.

Distributing Apparatus.

A small tank or reservoir is placed in the upper part of the house. It may be made of wood, lined with stout tinned-iron or sheet-tin, and covered in with a lid provided with a small opening for the admission of air, and for filling the reservoir with fresh oil whenever it is required. The capacity of the tank should be made proportionate to the number of lights that have to be fed from it. Its contents need rarely exceed one or two gallons. Over the outlet pipe I fix a cage of fine wire gauze, which keeps back any dirt occasionally found in oil.

A pipe leads from this tank to the lower parts of the honse. It may be carried along the waste-pipe, which is to be found in most modern honses. Branch pipes are carried to each floor. It is necessary to avoid lead or composition pipes, on account of the corrosive action which oils, especially vegetable oils, such as linseed, rape oil, and others exert upon lead. Tin pipes are accordingly used for the conveyance of the oil.

The branch pipe which conveys the oil to the little distribnting cistern may be fixed, like an ordinary gas-pipe, against the wall either inside or outside the room. The distributing cistern, consists of an open oblong box, about 6 to 8in. long, 3 to 4in. wide, and abont 3 to 4in. deep, into which the oil is delivered from a well-constructed stop-cock, which is soldered into the narrow side of the oblong box, and against which a somewhat smaller close box or oblong cistern is soldered, into which the oil makes its way from above by means of an inlet pipe connected with the small box by a union joint. At abont one-fourth from the top, inside the box, a very fine copper gauze is fixed. The oil, on passing through this sieve, is deprived of any accidental impurities, snch as chips of wood, bits of straw, &c., which might otherwise make their way into the stop-cock and cause an obstruction. The hermetically closed box can be readily got at by unscrewing the union joint, which is at the bottom of the auxiliary reservoir, if it should ever become necessary to remove any accumulation of dirt. The stop-cock is large enough to deliver a large stream of oil, whilst at the same time the action of the self-acting float is capable of checking the delivery down to a drop or two every few minutes. The distributing boxes can be made of all sizes, but as they constitnte merely temporary resting places for the oil, on its passage from the main tank at the top of the house to the burner or burners, they need not be made larger than is sufficient to hold a few ounces of oil. The china float is fixed to the tap by means of a metal arm or lever. The conical metal plug of the stop-cock may be either fixed by means of a screw button, or simply by means of a metal pin. The float is set so as to shut off the flow of the oil automatically as soon as the box or distributing-cistern is filled to about 1½in. in depth with oil. The china float is a circular double convex disc, pierced with a hole in the centre. Into this hole is fixed a piece of hard wood, to which the arm or lever is attached by a metal pin. The metal cone of the tap should work smoothly and regnlarly, and should be well ground in, so as to prevent any leakage whilst it is shut off. For better security, however, I fix a stop-cock just somewhat above the distributing-box, to shnt off the snpply when no oil is required from each floor. A stop-cock, fixed in the main-snpply pipe, just below the oil reservoir in the upper part of the building enables me likewise to shnt off the oil from the house as effectively as gas can now be tnrned off at the meter.

It is obvious that the little distribnting apparatus just described can feed one or two lights with the same facility with which it will feed 100 or more burners, provided they are all arranged on the same level, as seen in the model before you, since the tap will discharge the oil only in proportion as it is consumed. Burners placed at different heights must be snpplied from distributing cisterns placed at corresponding heights. For a single light, such as street lights, railway lamps, &c., I have also succeeded in perfecting another system of conveying the oil to the wick, which answers most admirably, but which I am not able to submit to you to-night, as the experiments have not been quite completed, and as certain necessary arrangements have yet to be gone throngh.

Lamps and Burners.

The constrnction of the lamp or burner differs, of course, according to the kind of oil—vegetable or mineral—which it is proposed to burn. I have until now only used ordinary colza and rape oil as well as petroleum oil, but there can be little or no donbt that any vegetable as well as light or heavy mineral oil can be burnt on the same principle. The consumption of colza oil, rape oil, &c., is rendered so much more easy as the distributing apparatus renders the supply of oil to the wick as regnlar as clockwork, and gives a light which remains steady for a considerable time, say 24 hours, and which can only be influenced by the gradual charring of the wick. The petroleum oil light possesses in this, as in other respects, an important advantage over the ordinary oil light, in so far as the wick chars much more slowly, and rarely ever gets distressed. No lamp has as yet been constructed which gives the same amount of light during a lengthened period of combustion. Carcel's clock-work lamp gives a light of such nniform brilliancy, remaining unimpaired for several hours after the lamp has been lighted, that, in France, for instance, its light serves as a standard for determining the illuminating power of coal gas. It is known to burn remarkably steady after the first hour, and to preserve this constancy of combustion from six to ten hours. The very slight change observed in the light is owing to the uniform level and snperabundant flow of the oil. The increase of brilliancy with the progressive bnrning during the first hour may possibly be accounted for by the decreasing qnantity of heat withdrawn from the flame by the neighbouring parts, in proportion as these become warmer, and also perhaps by the excess of oil being too great at the commencement, and becoming rednced to the proper quantity by the decreasing tension of the spring employed for working the pump.

A perfectly uniform light cannot be obtained from ordinary lamps on account of their construction, and more particularly from the action of the wick; the variations, however, which occur in the intensity of the light are confined within much narrower limits than in the case of candles, where a constant change is occurring. In many less perfectly-constructed lamps the diminution of light during six hours amounts to $\frac{1}{3}$, $\frac{1}{2}$, and even $\frac{4}{5}$ of the original intensity; it is only imperceptible in Carcel's and a few other lamps which produce their light with the least consumption of oil.

Upon what Principles should Lamps be Constructed.

There are four conditions required for a good lamp:—

1. A regular snpply of oil to the burning wick.
2. Means for regulating and varying (within certain limits) the height of the flame.
3. The regulation of the current of air, according to the nature of the illuminating material and the quantity thereof which is to be burnt.
4. The oil reservoir should be placed in such a position as not to throw a disturbing shadow into the illuminated space, without at the same time endangering the steadiness of the lamp.

All lamps may be divided, according to the methods adopted for feeding the wick with oil, into—

(*a*). Lamps in which the capillary action of the wick has to raise the oil from a lower oil level to the upper part of the wick; these are called *suction-lamps*.

(*b*). Lamps which are provided with a mechanical (hydraulic) contrivance for carrying oil in smallest possible proportions and in constant quantities to the wick; these are termed *mechanical* or *pressure-lamps*.

An ordinary light, with a floating burner, constitutes a snction-lamp, in which the distance of the level of the oil from the top of the wick remains always the same. This most rational construction of a lamp cannot, however, be applied to lamps on an increased scale of construction, and is of use only for lamps which have not to be moved, and which have to produce only a weak light. Among the other suction lamps of a most simple yet faulty construction, are the lamps in which the oil vessel is placed sideways (as, for instance in the ordinary kitchen or study-lamp), or below the burning wick. In both kinds of lamps the wick suffers from an irregular supply, varying with the ever changing level of the oil; they produce therefore a varying light. A more regular supply of oil to the wick can be insured by constrncting the oil-vessel upon the principle of the common bird fountain. The lamp requires, in fact, two oil cisterns, an outer one, from which the burner is fed, and an inner or inverted vessel, from which the oil is supplied to the outer vessel, in proportion as it is consumed. When the lamp has been lighted for some time, and the oil in the outer vessel has sunk below the mouth of the vessel, air-bubbles enter, and take the place of an equal bnlk of oil, which makes its way into the outer vessel, thereby raising the oil-level until the mouth of the inner vessel becomes again closed. In all lamps of this construction the height of the oil in the burner is snbject to slight fluctuations, which produce, however, a perceptible variation in the supply of the burner, and, consequently, in the light produced by the lamps. Of other lamps, such as the so-called hydrostatic lamp, I need not speak, as they are little nsed now, having been found far too complicated and clumsy.

The ingenious mechanism in the different mechanical or pressnre-lamps, in which springs or pumps are made to force up the oil from the oil reservoir below the burner to the top of the wick, deserves to be admired. These lamps, known by the name of pump-lamps, moderator-lamps, Carcel's clock-work or mechanical lamp, convey the oil with almost faultless regularity to the burning wick. The moderator-lamp, on account of its greater simplicity, its greater cheapness, and pleasing shape, has now, for the most part, replaced the Carcel-lamp, in which the oil is raised by a Priest-pump, so called after its inventor, set in motion by a spring which can be wound up. All mechanical lamps convey more oil to the wick than can be burnt, causing a constant overflow of oil—most ample in large lighthouse lamps. The wick can, therefore, be raised considerably above the edgc of the burner. Thus, less heat is conducted away from the flame by the metal burner, and the wick does not char so rapidly, whereby a more regular flow of the oil is secured—a condition which is all-important when heavy and less fluid vegetable or animal oils have to be bnrnt. The principle underlying all mechanical lamps, viz., the pleutiful supply of oil to the wick, so as to canse a constant overflow, is inapplicable in lamps which are constructed for the consumption of mineral oils, such as naphtha, camphine, shale oil, photogen, solar oil, and paraffin oil. The principal condition which has to be complied with is a well-regulated and abnndant supply of air, in order to consume the very large quantity of carbon which enters into their composition. To prevent smoke, it is also necessary that the wick should receive as little oil at a time as possible, and that this oil shonld reach the flame as hot as possiblc.

It is obvious that compliance with this latter condition reuders the use of oils all the more accessiblc, which can only be burnt by a copious snpply of air, deflected from both outer and inner air currents into the flame. This is done in various ways. In the so-called paraffiu lamps the wick tnbe is capped with a metal cone, which slightly rises above the level of the burner, and a cnrrent of air, as in the case of argand burners, is ofteu thrown into the inner side of the flame by means of a moveable button, the so-called Liverpool button. The air curreut is fnrther regulated by glass chimneys of varying heights, according to the nature of the oil and the size of the flame. It is impossible to pay too much attention to the chimneys. I have found that one and the same burner produces as much as four times the amount of light when supplied with different chimneys. I also observed that the chimney influences to a very grcat extent the size or height of the flame, and that the latter is sometimes contracted and squeezed into a pyramidical form by the chimney, whereby the illuminating power of the flame is materially reduced.

To sum up briefly this review of tho different systems in use for conveying the oil to the wick, and the various lamps—at all events the more important ones which have been made—it will be clear that tho lamps which arc constructed on the most correct principles are at the same time of a highly complicated natnre, and far too ingenious for every-day use; also, that mineral oils are burnt with greater advantage by a totally different system of constant oil-snpply, although I may mention that I have succeeded in constructing a moderator lamp which burns petroleum very nicely. I believe that the new method of feeding lamps with petroleum, proposed by me, has at least the merit of great simplicity, whilst it complies most rigorously with the reqnirements of a steady and uniform oil snpply to the lights.

Improvements in Burners.

I have used both argand and flat burners for the consumption of mineral oils in lamps, and have succeeded in what will probably astonish many gentlemen in the room familiar with lamps, viz., in burning the oil by means of the ordinary argand burner and cotton wick dipping into the oil, without being inconvenienced by any overflow and dropping of oil, the wick projecting but slightly from the burner. This, you will agree with me, can only be done when the oil is supplied to the wick with the greatest possible regularity, and, *vice versâ*, it affords a clear proof that I have snccceeded in so supplying it.

The difficulty of employing argand burners for the purpose of burning light mineral oils is considerably increased on account of the more mobile nature of the fluid, and any overflow from the burners can only be prevented by the nicest adjustment of the oil supply.

The argand burner is already such a perfect piece of apparatus that you will not expect to hear from me that I have materially improved upon it. I have been able, howevcr, with the aid of Mr. White, of whose mechanical skill it would be difficult to speak too highly, to introdnce several improvements in the constrnction of argand burners, for the consumption of petroleum oil, which enable me to employ burners of considerably larger size than have, I believe, hitherto been employed. By dispensing with the Liverpool button for throwing air into the inner part of the flame, the latter increases considerably in height, giving a proportionately increased illuminating power.

The movement imparted to the wick by means of a worm, whercby the inner tube, or wick-holder, is worked from the onter gallery tube, which supports the glass chimney, by means of a pin fitted into the serpentine groove of the inner tube, usually entails a very unsightly breaking up of the flame into as many distinct divisions as there are brass stays, or rods, for connecting the outer with the inner tube, owing to the splitting-up of the air draught into several distinct currents. A perceptible loss of illuminating power is known to result from these defects; the burners are more liable to be influenced by air-currents, which often cause them to smoke most disagreeably. I have substitnted fine connecting-pins betweeu the outer and inner closely-fitting tubes, and thereby entirely obviate these drawbacks to a pleasing and steady flame. This improvement applies eqnally to argand burners used for burning colza or mineral oils.

The movement for raising or lowering the wick, known as the rack-and-pinion movement, which depends upon turning a key that works the pinion, was found to be defective, as the expansion of the metal tubes by the heat, and the contraction on cooling, played havoc with the most perfect fittings, and caused frequently a slight leakage through the holc in which the key works. In order to overcome this defect, I have placed the key above the level of the oil in the wick tube, and have sinco found that no leakage need be dreaded from this cause.

I employ argand burners of different sizes, burning wicks varying in diameter from $\frac{5}{8}$ to $1\frac{3}{4}$in. It has, however, been found that the larger argands give proportionally less light than the smaller sized burncrs, a ratio which is the reverse of that observed in the case of argand gas burners. This applies to the earlier experimental photometrical testings. I hope to overcome this loss of illuminating power, however, by employing central tubes, which deflect the current of air into the flame, whilst, at the same time, the quantity of air to the inner part of the argand flame can be brought under thorough control. The proper conditions for any alteration of this kind can only be studied by patieutly watching the effect produced, and I must therefore abstain frou going further into this question, beyond mentioning that I am hopeful of coustructing burners larger in diameter, with every prospect of success.

Theoretical Consideration of the Nature of Luminous Flames.

I found that the illuminating power of argand bnrners, as well as flat lights, is considerably increased by an appropriate and well-adjusted supply of the illuminatiug material. It may be readily conceivcd that, with a mobile liquid like petrolcum oil, which is easily vaporised, it is a matter of grcat importanco to placo the supply of oil to the wick at such a hcight as to allow the wick uot only to suck up the oil frcely, and to convey it without hindrance aud with the utmost regnlarity to the flame, but to ntilise also tho hcat engendered by the combustion of the oil, and which is communicated, to somo extent, by conduction aud radiation to the metal tubes in which the wick is encased, and in which the oil is supplied to the latter, in order to vaporise a portion—perhaps not an inconsiderable portion—of the oil before it comes in contact with the air

supplied to the burner from the outside and inside of the flame. That this is actually the case may be seen when a light is allowed to burn for some time, until the wick-case has become heated to its maximum temperature, and is then suddenly blown out and rekindled after a few moments. The vapour of the oil is seen to burn above the burner, leaving a non-luminous dark space between the wick and the flame. Cold petroleum oil does not inflame, even when a light is held closely over the surface of the oil. It is, in fact, by this very test that the value of different samples of petroleum is determined. The point of ignition is observed by a thermometer, and no oil, the vapour of which inflames below a temperature of 90 deg. F., is now allowed to be sold, according to an Act of Parliament passed in the year 1868. It will strike you, as it struck me, that we arrive at the right condition for the burning of easily volatilisable oils, when they are vaporised previous to their introduction into the flame, and that a higher illuminating power is obtainable from the same illuminating material when conveyed to the flame in the form of vapour heated nearly to the point of ignition. Petroleum oil is, after all, not separated from coal gas by such an insuperable line of demarcation. The latter is a vapour at the ordinary temperature, and the petroleum oil which I use becomes converted into a vapour at the temperature of about 340 deg. Fah.

Moreover, gas engineers have shown us that the temperature at which coal gas is consumed materially influences its illuminating power; that, for instance, gas which is conveyed through several miles length of gas-mains loses in illuminating power, on account of the condensation of the less volatile hydrocarbon vapours, such as benzol, napthaline, and others, contained in the gas; that during cold weather the illuminating power of the gas recedes and that the exhaustion of the coal in the retort-house cannot be carried so far as during warm weather. They are likewise aware of the fact that during the warm season of the year the gas remains more thoroughly charged with hydrocarbon vapours, rich in illuminating power, and that, consequently, a more thorough exhaustion of the coal is possible.

I may also remind you of the numerous ingenious devices resorted to by various inventors, from the late Mr. Mansfield, who was, I believe, the first to distil benzol on a manufacturing scale, down to the more recent enthusiasts in the cause of improving coal gas by charging it with hydrocarbon vapours, viz., the various so-called naphthalising processes, with which most of you, gentlemen, are no doubt acquainted. We all know of the surprising effect which can be produced by passing coal gas through benzol, or some other more volatile hydrocarbon, and we also know how coal gas dislikes to be improved in this apparently simple manner. Attempts made on a large scale in the City of London, and in other places, have failed, owing to the difficulty of keeping the more condensible vapour in suspension in the gas. It is even possible—and a most ingenious lighthouse lamp has been actually constructed on this principle—to procure a beautiful light by merely passing air through very light mineral oils, slightly heated, and to burn the mixture of air and gas with splendid effect from a close argand burner—if this name may still be applied to such an illuminating apparatus, by making use of the precautions observed in a Hemming's oxy-hydrogen jet. This shows, more than anything else, how closely coal gas and light hydrocarbon vapours are allied to each other, and how the same things holds good for the one and the other under different conditions of temperature.

Every practical gas-burner maker is familiar with the influence which the temperature possessed by the gas when it issues from the burners, exerts upon its illuminating power. One rule, I believe, is to allow the gas to issue under as low a pressure as possible, and a most ingeniously devised argand burner has been constructed by an eminent gas engineer at the West-end, which burns the gas to the greatest advantage, but which hitherto has not passed out of the region of the gas-testing room (where I believe it is doing good service) into general practice, because the least draught of air causes it to smoke most inconveniently. Burners have been constructed also, in which the flow of the gas is checked by wire gauze, cotton wool, &c., placed as near as possible to the point of issue of the gas. Metal burners get hot, and the longer the gas is retained in the heated part of the burner, before it issues the greater the illuminating power it produces. You are also, no doubt, familiar with the contrivance of placing a small piece of platinum into the flame of ordinary gas burners, and we are informed, on the authority of Dr. Letheby, that the illuminating power of gas is increased 63 per cent. by this simple contrivance.

If, then, the illuminating power of coal gas can be improved by consuming the vapour at a higher temperature, or by charging it with easily vaporised hydrocarbons, it deserves certainly the serious attention of every practical lamp maker, to study carefully how the same condition can be best complied with in the burning of mineral and other oils.

Now, I think that the burners which I have the pleasure of exhibiting to you, comply pre-eminently with these conditions. I may mention that I found this out only by carefully watching the influence which a lower or higher supply of oil had upon the flame. I was partly led to it also by endeavouring to realise a most necessary condition with which I felt that the new lights should comply, viz., that the burners should not discharge any oil. This is really not so easily attainable as may be thought at first sight, and I had no little trouble before I arrived at the right conditions. I found, however, that on lowering the supply pipe to the argand burner an inch or more, so as to lower the level of the oil in the wick case to the same extent, the illuminating power of the same burner was increased as much as 30 to 50 per cent., without entailing a corresponding increase in the consumption of petroleum. The fact was, that in one burner (the large size one) I discovered, on closely watching one day, that some vapour was issuing from a very fine hole just below the key, and that this vapour burnt when I brought a light near it. This observation proved that the petroleum vaporises, to a great extent, before it gets to the top of the wick.

The theoretical explanation for this fact I found in an admirable lecture, delivered by Dr. Frankland, at the Royal Institution, June 12, 1868. from which I quote somewhat fully, as the evidence which Dr. Frankland brings to bear upon this interesting subject quite coincides with my own observation.

Dr. Frankland states that the source of light in a luminous gas or candle flame has been held by different chemists and physicists to be derived from "the ignition of solid matter in the intense heat developed by the chemical changes attendant on combustion."* It was thought that whenever hydrocarbons are imperfectly burnt "there is a deposition of carbon, and this temporary deposition of carbon was said to be an essential condition for the production of the whole light required in an ordinary flame." † Another authority tells us "that the illuminating power of the gas is due to carbon particles, which are afterwards burned nearer the border of the flame." ‡

Again we read: "That the brightness, or illuminating power of a flame, depends not only on the degree of heat, but likewise on the presence or absence of solid particles, which may act as radiant points. A flame containing no such particles is said to emit but a feeble light, even if its temperature is the highest possible." §

Now this view, commonly held by scientific men, based upon Sir Humphrey Davy's researches, has been exploded by Dr. Frankland, who showed that there are many flames possessing a high degree of luminosity which cannot possibly contain solid particles. The flame of metallic arsenic burning in oxygen, for instance, emits a remarkably intense white light. Phosphorus burning in oxygen emits a dazzling light, surpassed by few other burning bodies, and is converted into phosphoric anhydride, a body which is volatile at a red heat, and it is therefore manifestly impossible that this substance should exist in the solid form at the temperature of the phosphorus flame, which far transcends the melting point of platinum.

For this and other reasons, to which I need not refer, Dr. Frankland considers that incandescent particles of carbon are not the source of light in gas and candle flames, but that the luminosity of these flames is due to radiations from dense but transparent hydrocarbon vapours, and it is to the behaviour of hydrocarbons under the influence of heat, that we must look for the source of luminosity in a flame. These gradually lose hydrogen, whilst their carbon atoms coalesce to form compounds of greater complexity, and consequently of greater vapour-density. Thus, olefiant gas (C_2H_4) the chief illuminant in coal-gas, forms naphthaline ($C_{10}H_8$), when the vapour-density augments from 14 to 64. These and others are some of the dense hydrocarbons which are known to exist in a gas flame, but there are, doubtless, others still more dense; pitch, for instance, must consist of the condensed vapours of such heavy hydrocarbons, for it distils over from the retorts in the process of gas-making.

Candle flames are similarly constituted. Dr. Frankland has also shown that a candle burns with feebly-luminous light, under a low atmospheric pressure (on the top of Mont Blanc, for instance), and that jets of hydrogen and carbonic oxide, two gases which at the ordinary atmospheric pressure burn with little luminosity, burn with a markedly augmented light when burnt in oxygen under a pressure gradually increasing to twenty atmospheres. If it be true, then, that dense gases emit more light than rare ones when ignited, as Dr. Frankland has conclusively shown, it follows that the vapour of hydrocarbons, such as those contained in petroleum oils (mostly homologues of marsh gas and olefiant gas, two of the chief constituents of coal gas), and which are much denser than these simpler hydrocarbons, fully account for the greater intensity of the light which these oils produce when burned in properly constructed lamps. That these oils can be burnt without soot, which after all is not elementary carbon, but always contains hydrogen, and that great luminosity is attainable without the presence of solid

* Prof. W. A. Miller. † Prof. Williamson. ‡ Balfour Stewart.
§ "Watt's Dictionary of Chemistry.

particles of carbon in the flame, is amply illustrated by the lights which I am able to exhibit before you. The difficulty to contend with is not so much how to burn the vaponr of mineral oils, but how to prevent their volatilisation in a more or less unburnt or partially burnt condition. Everybody is familiar with the unpleasant odour which so-called paraffin lamps do occasionally emit. This no doubt arises from imperfect combustion, for on first testiug photometrically the light produced by the different size burners it was found, in fact, that the larger size argand burners, giving the light of as much as forty sperm candles, consumed proportionately more petroleum than the smaller size burners. This was evidently owing to the passing of some portion of the oil in the form of unburnt or incompletely burnt vapour through the mantle of the flame, and as it was contrary to the well-established fact of gas producing a considerably increased illuminating effect when burnt in larger quantities than it produces when burnt in small qnantities, I endeavoured to account for it by the theory so ingeniously advanced by Dr. Frankland.

PETROLEUM.

Since the years 1858 and 1859, extensive borings, for the purpose of obtaining petroleum or rock oil, were made in Pennsylvania and Ohio. In the former State, the most extensive and successful sinkings have been made between the Alleghany River and the western limit of the State. Along that river native springs of petroleum have existed, which, oozing through the superficial clay, have now formed a tenacious, pasty mass. In the vicinity of these springs, the artificial wells have been made by sinking a bore deep enough to reach the thin layer of bitumen flowing between the strata. As the whole of this oil region is underlaid by what is known to geologists as the coal mcasures, the petroleum is probably derived from the natural separation of the bitumen from the carbonaceous portion of the coal, which oozing upward from faults or fissures in the coal seam, drains off between the strata, and follows the inclination of the latter until it reaches the surfacc in some denuded portion of the coal bed. This gradual oozing over extensive surfaces yields a large supply of liquid oil, which has been extensively brought into the market, and has almost entirely superseded the mineral oils formerly distilled from bituminous deposits, liquid or solid, found in various parts of the world, among which the Burmese naphtha or Rangoon petroleum deserves special mention.

The neutral oils distilled from bitumen, bituminous schists, coal, rock oil, &c., are composed of liquids having their specific gravity and boiling points so close to each other, that it is a matter of great difficulty to isolate them so as to examine their properties. Bnt, although the photogenic oils derived from these sources are not always the same whcu viewed chemically, their photometric value may yet be precisely the same. According to the proportion of carbon contained in the oils, they require a more or less plentiful supply of air for their proper combustion, and the cotton-wick would probably be affected differently by heavier than by lighter oils. The oil which I usually burn is American petroleum of specific gravity, ·795. It boils at about 340 deg. F. I have not had time as yet to test both lighter or heavier oils, bnt have no doubt that they can be burnt with equal facility by the apparatus before you. The wholesale pricc of the oil is 1s. 6d. per gallon. It is not difficult now to procure properly purified petroleum, and I have no donbt, if the demand for well purified petroleum were to increase, that the distillers would finds means and ways to thoronghly purify the oil used for burning in lamps.

(To be continued.)

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

ON THE EXAMINATION OF THE BESSEMER FLAME WITH COLOURED GLASSES AND WITH THE SPECTROSCOPE.

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I. EXAMINATION WITH COLOURED GLASSES.

In the Bessemer process, the progress of tho decarbonisatiou is determined chiefly by the appearance of the smoke, flame, and sparks which are emitted from the apparatus. Owing to the rapidity with which the reactions take place, it is highly important to catch the exact moment when the blast should be turned off. This is indicated by tho colour and brightness of the stream of gas issuing from the converter, and by this the moment of total decarbonisation can generally be accurately determined by the naked eye. When, however, pig-iron of certain qualities is used (manganiferous iron, for example) this determination is very difficult; even those who have had mnch experience make freqnent mistakes and find it impossible to produce the same qnality of steel at every blow.

In order to intensify these flame-indications, use has been made of the spectroscope, and also of various combinations of coloured glasses. The former was first attempted by Dr. Roscoe, and the latter by Mr. Rowan at the Atlas Works.

Mr. Rowan experimented with a great varicty of coloured glasses, and obtained the best results by using three glasses, two ultramarine-blue and one of dark yellow. This little instrument, or chromopyrometer, as he terms it, is now in daily nse at the Atlas Works, its indications being so marked and unmistakable as to render its use safe in the most inexperienced hands.

The following experiments were made at the Bessemer Steel Works of John A. Griswold and Co., in Troy, while pursuing the chemical course in the Winslow Laboratory of the Rensselaer Polytechnic Institute. In my observations on the flame I made nse of the spectroscope, and also of a combination of coloured glasses. This combination consisted of two light yellow glasses and a blue one, through which the sunlight appeared of a deep pnrplish-blue tint; and as it differed slightly from Rowan's, it gave somewhat different results.

In order to reproduce the appearance of the flame at the different stages of the process, I prepared a plate consisting of abont a hundred varieties of colours and tints, all of which were numbered and thus referred to a table which indicated their composition. They were also arranged to be seen with either a light or dark background. The use of this plate was of necessity limited to daylight, bnt the illustration and description are given as occuring at night in order to show its illuminating power.

At the beginning of the process that which issues from the converter does not appear to be a true flame, but only an illumined stream of gas carrying with it innumerable red-hot pellets of irou. This gas has scarcely any illuminating power, extends bnt for a short distance from the mouth of the converter, and is sometimes sheathed with a whitish smoke. Seen throngh the glasses, the flame and sparks have a deep crimson colour, the converter is invisible, and at the base of the flame is a crimson band which continnes throughout the process.

As the reaction continues, this stream of gas grows brighter and more elongated, and, after a few minutes a small pointed whitish flame appears, which snddenly increases in size. At this instant the blast-pressure falls from 20 to 18 pounds.

When viewed through the glasses, the upper part of the converter comes dimly into view, and the flame and pellets of iron appear of a lighter colour, while the fragments of slag which begin to be thrown out are of a deep red. This difference in shade betweeu the iron and slag thrown out is, probably, entirely owing to the lower temperature of the latter, for the reason that while the iron is discharged from the metallic bath the slag is washed up on the sides of the converter, and can be seen clinging around its mouth in a spongy mass until detached and thrown out by the blast. The greater porosity of the slag and its cousequent more rapid cooliug would also canse a difference of temperature.

In the second period the discharge of slag increases, and the flame is very bright and illuminating, with occasional dark streaks. Through the glasses at the beginning of this period the flame is of an ashy blue colour with streaks and flashes of crimson, the edges being sometimes of a purplish hue. At this point surrounding objects are illuminated, and the converter becomes distinctly visible. A wreath of crimson is seen surrounding the flame where it strikes the chimney. By the middle of this period the crimson almost entirely disappears from the body of the flame, leaving ouly a slight cone at its base, and a border of greenish hue makes its appearance, and gradually grows more decided. Streaks of a dark blue colour are also seen in the body of the flame.

The beginning of the third period is scarcely indicated to the naked eye, though the flame becomes somewhat weakened, and after a few minutes shows dark streaks running through it. Through the glasses at the commencement of this period the rose-coloured cone begins to expand and deepen, the greenish sheath is more decided while streaks of dark and green are visible. After a few minutes the change becomes very rapid, a few seconds only being required to reduce the flame from rose-colour to the deep crimson non-illuminating gas, as at first, and again the converter is lost to view, by which time the blast should have been turned off.

The gradual fading of the crimson from the beginning of the blow and its deepening at the termination of the process, as well as the crimson band at the base of the flame and tho wreath of crimson surrounding the flame at the chimney, tend to confirm Mr. Rowan's views, which are, that the different shades of crimson are due to changes of temperature. The stream of gas which comes from the mouth of the converter at the beginning of the process, being illumined from within, derives its colour from the metallic bath, the temperature of which, owing to the com-

bustion of silicon, increases more rapidly during this period than at any other.

The crimson band at the base of the flame, and the wreath of crimson at the chimney might also be accounted for by this theory. The flame rushing from the mouth of the converter has a tendency to create a vacuum at its base around the converter's edge, and thus to cause a wreath of flame to pass over this surface, and by consequent cooling produce the crimson band. The wreath of crimson at the chimney may be also due to the cooling of the flame consequent upon deflection.

It is true we have a seeming contradiction to this theory in the rose-coloured cone extending from the base at the centre, which we would naturally consider the hottest part of the flame; but, as in the flame of the Bunsen burner, the hottest part is in its outer sheath, the conditions of combustion in both being similar, it is probable that that part of the flame occupied by the cone is at a lower temperature than that surrounding it.

The green streaks in the flame are most intense when the manganese spectrum is brightest; and as the colour of the flame when the spiegeleisen is added is also green, we are led to suppose them due to the presence of manganese.

On two occasions simultaneous observations were made with the spectroscope and the coloured glasses; but with the exception of that just mentioned, and the changes at the commencement and termination of the blow, no striking coincidence was noticed.

II. Examination with the Spectroscope.

The science of spectrum analysis is yet in its infancy, and there has been no scientific investigation, perhaps, which has been more contradictory in its results than that of the Bessemer flame. The first application of the spectroscope to the analysis of the Bessemer flame was made in 1862 by Dr. Roscoe at the works of Messrs. John Brown and Co., in Sheffield. Soon after this it was in constant use in Brown's works for controlling the process. It was next introduced at Crewe, and from there said to have been taken to Seraing, in Belgium, in 1865. Roscoe's account of the general appearance of the spectrum has not altogether been verified by subsequent observers. His not having seen any line beyond 80 deg. indicates an imperfection in his instrument. He, also, is the only one who claims to have seen the sodium line as an absorption-band, or who professes to have detected the lines of nitrogen and hydrogen in the Bessemer spectrum. His spectroscope was so arranged that the spectrum of the Bessemer flame was seen in the upper half of the field of view, while the spectrum with which it was to be compared was seen immediately below. The spectrum of the flame was thus compared with the following spectra:—

1. Spectrum of electric discharge in carbonic oxide vacuum.
2. Spectrum of strong spark between silver poles in air.
3. Spectrum of strong spark between iron poles in air.
4. Spectrum of strong spark between iron poles in hydrogen.
5. Solar spectrum.
6. Carbon spectrum—oxyhydrogen blowpipe supplied with olefiant gas and oxygen.

The coincidences observed were very few, and totally failed to explain the value of the Bessemer spectrum. The lines of the well-known carbon spectrum did not occur at all, either as bright lines or absorption-bands, nor was any coincidence observed between the lines of the Bessemer spectrum and those of the carbonic oxide vacuum tube. The lines of lithium, sodium, and potassium were strongly marked and identified with certainty. He found that three fine bright lines between E and *b*, shown on the plate at 66½ deg., 67 deg., 67½ deg., coincided with those of iron; and in place of the red hydrogen line C, he discovered a black band, which he considered an absorption-band, and states that it is better defined in wet than in dry weather.

In Austria, Professor Lielegg followed up this subject with great perseverance. and gave more extended accounts of the varying character of the Bessemer spectrum during the different stages of the process. His experiments were made at Gratz, where the spectroscope was afterwards used with great success in controlling the Bessemer process; but at Königshütte, where dark gray manganiferous iron was used, it was found that the indications which in other works so plainly determined the moment of decarbonisation were unreliable. In this case, the lines whose disappearance is to indicate the exact point of time for ending the process, disappear too soon. During the period in which the spectrum is brightest, among the glowing vapours and gases that stream from the converter, carbonic oxide, next to nitrogen, is most abundant, and it is for this reason that the first investigator, Roscoe, expressed himself as confident that the numerous lines of the spectrum were caused by this gas, although he could obtain no coincidence.

Brunner* states that "no part of the Bessemer spectrum is ever visible in the flame when the converter is heated for the first time after being re-lined, but that when the lining is not new, Lielegg's group of green lines ($CO\tau$) appears in the spectrum, which then contains also the lines of potassium, sodium, and lithium." From which he concludes that this spectrum is not to be identified with carbonic oxide, but must be produced by other constituents of pig-iron. Others state that the Bessemer spectrum is sometimes visible while the converter is being heated after a blow. I made an observation of the flame from the converter while it was being heated the first time after being re-lined, and obtained with great distinctness the potassium, lithium, and sodium lines, but have not under any circumstances detected any other lines while the converter was being re-heated.

Lichtenfels, by a series of simultaneous comparisons of the manganese with the Bessemer spectrum, found the lines in the blue and green fields to completely harmonise in the two spectra. The violet manganese line which had been seen by some he could not detect in either of the spectra. I have never observed it, but Dr. Wedding, who has summed up the observations of others, states that he has repeatedly seen it. Its position is at 135½ deg.

The instrument used in my investigations was constructed by Alvan Clark, of Cambridge, and consists of an equiangular flint-glass prism, in a metallic box, into the sides of which at the requisite angles are screwed an inverting telescope with a magnifying power of six, and a tube containing the adjustable slit and lens for rendering the rays parallel; also a tube with a scale, which is placed at such an angle that it is reflected from the surface of the prism through the telescope to the eye; it can be so adjusted as to appear along the upper edge of the spectrum. I was provided with Bunsen's plates of spectra on a large scale, and in order to adapt them to the scale in my instrument, I took the spectrum of the sun and obtained Fraunhöfer's lines with great distinctness. Two characteristic lines in the solar spectrum were then noted, one of which appeared at 37 deg. and the other at 117 deg., and a space measured equal to their distance apart as given on Bunsen's scale. This was divided into eighty equal parts, and the division extended in both directions. By the application of this scale to Bunsen's, I found that the remainder of Fraunhöfer's lines in my instrument exactly coincided with their position on his plates. The correctness of the new scale was also proved by other coincidences. By moving the prism, Fraunhöfer's lines will vary slightly in their relative distances apart, but in no possible position in which I could place the prism could I obtain the sun-spectrum as given by Wedding in connection with the Bessemer spectrum; if the spectrum given by him was obtained by the use of bisulphide of carbon in his prism, that substance causes a greater variation than I had supposed.

I have recorded the results of twenty-five observations on the Bessemer flame, most of which were taken at a distance of about thirty feet from the flame, through I have stationed myself at intermediate points between that and the flame; at one time sitting so close as to be almost scorched. Nearly all my observations were made at night and the lines obtained much better defined than when seen in diffused sunlight.

The record of my observations was kept as follows:—Five columns were ruled, headed—

Degree.	Colour.	Brightness.	Time.	Remarks.

Note was made of the dark bands as well as the bright ones, both of which were classed according to their distinctness, as very bright, bright, faint, and very faint. In the time column was noted the number of minutes after the commencement of the blow at which the lines appear.

At the first two or three observations I attempted to make a thorough note of the changes as they occurred throughout the whole spectrum, but afterwards abandoned it as utterly impossible, as at the beginning of the second period, the lines come in so fast and the changes are so rapid that they cannot be accurately noted at the exact moment of their occurrence. I therefore confined myself to a few degrees at each observation, and by this method was enabled to note accurately, and at the exact moment of their occurrence, slight changes which otherwise might have escaped notice. Note was also taken of the changes in the general appearance of the whole spectrum during the successive stages of the process. After having made half a dozen observations, while viewing the spectrum of the flame from the converter while it was being heated for another charge, it was discovered that a movement of the eye before the eye-glass occasioned a similar movement of the lines of the spectrum along the scale, on which their position could thus be made to differ more than half a degree. I have seen no notice of this in the statements of others, and it may account for some of the apparent discrepancies. Thereafter, when taking the readings of any of the lines, the position of the eye was so adjusted as to bring the sodium line exactly at 50 deg. Owing to the extreme brilliancy of the flame the aperture may be made

* Van Nostrand's *Eclectic Eng. Mag.*, vol. i., page 508.

exceedingly narrow, and thus the many lines of the spectrum, which with a duller light and broader gauge would be blended together, may be separated.

At the beginning of the blow, the spectrum is continuous and very faint, and generally extends from 35 deg. to 120 deg., covering about three-fouths of the length attained in the second period. This increases slightly in extent and brightness until the appearance of the sodium line. This line appears at the end of the first period at the beginning of a more decided flame. It comes flashing through from one extremity to the other for an instant, and then disappears only to return the next instant in brighter flashes, which are continued for about a minute, by which time the line becomes permanently established. On one occasion the sodium line, instead of flashing and disappearing as usual, continued visible after a few seconds, and expanded and contracted in width almost isochronously until it became permanently established. The appearance of this line indicates the termination of the first period. This period I have found to vary in extent from three to seventeen minutes in blows lasting from thirteen to twenty-seven minutes. None of the other lines make their appearance in vivid flashes as does the sodium. The lithium line becomes visible three or four minutes after the first flash of the sodium. It is very faint at first but soon becomes quite distinct, and lasts through the blow. The vivid flashing of the sodium line may be accounted for by the exceedingly small amount of sodium required to produce its spectrum—an amount not exceeding 1-180,000,000th of a grain. The slightest momentary combustion taking place in the stream of gas from the converter, would at that instant render glowing a sufficient amount of the vaporised sodium to produce its spectrum, and thus occasion the flashes so characteristic in the first appearance of that line. Lithium exists in a much smaller quantity, and requires 1-6,000,000th of a grain, or thirty times that given for sodium. By the time the lithium line is established the red potassium line at 23½ deg., and occasionally the violet line at 135 deg., appear and the blue and green fields become divided into bands, which are so rapidly resolved into bright and dark lines, that it is difficult to note the exact time of the appearance of each. The spectrum increases to a dazzling brightness, and extends itself in both directions until it reaches from 23½ deg., to 140 deg.

During the third period the spectrum becomes more brilliant, and the lines more distinct. Several new lines make their appearance in different parts of the spectrum, of which the ones at 51½ deg. 57 deg. and 67 deg. are well defined, while others are faint and not always visible; some of them appearing only toward the close of the last period. In viewing the lines in the most refracted part of the spectrum, it has been repeatedly observed, both by myself and others, that these lines were more strongly marked when entering the eye at an angle than when viewed directly. That this was not imagination is proved by repeated identification of lines at the same point on the scale.

At the termination of the blow the lines are rapidly swept away, sometimes in the inverse order of their appearance, but more generally they disappear within the space of two or three seconds, leaving a continuous spectrum as at first, though somewhat brighter. Sometimes the sodium and lithium lines are swept away with the others, and at other times they remain visible. In either case the change is very decided, and does not generally occupy more than three seconds. In the course of my observations, thirty-three lines have been detected, as given in the table below.

Some of the lines given by Lielegg I have failed to find, but have detected others not given by him.

1st Period, 23½, 35, 50, 135.

2nd Period, 23½, 35, 43, 44, 44½, 45½, 46, 47½, 48½, 50, 52, 53, 56, 56½, 61½, 62, 62½, 63, 65, 66½, 67½, 70, 72, 120, 135.

3rd Period, 23½, 35, 43, 44, 44½, 45½, 46, 47½, 48½, 50, 51½, 52, 53, 56, 56½, 57, 61½, 62, 62½, 63, 65, 66½, 67½, 70, 72, 100, 102, 103, 105, 108, 135.

Among the dark bands detected, the most intense occurred at 44—46, 51—55, 56—58, 62—64½, ; others were found at 33—34½, 36½ 37½, 38½, 40, 68—72.

Many of the dark bands were crossed by bright lines.

I have repeatedly observed the dark band considered by Roscoe to be a hydrogen absorption line, but have not noticed that its intensity varied with the dampness of the weather. Whether it is an absorption-band or not can be determined by a series of observations continued through wet and dry weather. If this proves to be a hydrogen line, the Bessemer spectrum will be found more complicated than is generally supposed. It has been thought by some that the dark bands in the spectrum are absorption lines due to the cooling of the outer sheath of flame, but it is more probable, that although the pellets of iron and slag tend to produce a faint continuous spectrum; yet in contrast with the very brilliant lines it appears discontinuous, the dark bands being merely intervals between the bright ones. The iron spectrum has not been satisfactorily identified. It has been suggested that the brightness and size of the lines of the Bessemer spectrum do not allow the iron lines to appear. In comparing the Bessemer spectrum with Bunsen's spectra of nickel, cobalt and calcium, no coincidences were observed except two or three in the latter spectrum. The brightest calcium line, however, was not visible in the Bessemer spectrum. The Bessemer spectrum contains yet many mysteries to be solved, among which is the cause of the non-appearance of the lines of the spectrum at the beginning and termination of the blow.

This was readily solved when the numerous lines of the spectrum were attributed to carbon, but in proving them to be caused principally by manganese, their disappearance is not so readily accounted for.

One theory to account for it is that the luminous power of the flame is too small at the beginning and end of the process to produce a spectrum. In regard to this it may readily be shown that the brilliancy of the spectra of incandescent metallic vapours does not depend upon the illuminating power of a flame, but upon the heat of the flame into which they are introduced. For instance, the spectra are more distinct in the non-luminous flame of a Bunsen lamp than in the ordinary luminous gas-flame. If we take the theory as referring to the feebleness of light given off by those substances in the flame which produce the spectrum, it will resolve itself into the one of change of temperature, notwithstanding the fact that the illuminating power of flames of the same temperature varies with the composition of the gas, because there is evidently enough sodium in the flame to give its characteristic line; hence, whatever might be the illuminating power of the flame, if the heat is sufficiently intense the sodium line *will* show itself.

Dr. Wedding adopts the theory that the absence of the spectrum at the beginning and termination of the blow is because the absolute quantity of the bodies volatilised producing the spectrum is at these times too small. His reason for holding this view are as follows:—"A trace of sodium will give its characteristic line, but, according to Simmler, a much larger quantity of manganese is needed to obtain a recognisable reaction than that which can be detected by the well-known blowpipe reaction with carbonate of soda. Consequently, spectrum analysis does not depend alone upon the *presence* of a body, but also upon the presence of a certain quantity. And although manganese is always left in the iron, it may not be left in sufficient quantity at the termination of the blow to produce the spectrum, and for this reason the lines disappear."

To this theory there are some strong objections. 1st. If we take the manganese in sufficient quantity, and hold it in a flame the spectrum will increase in brightness until a uniform temperature is attained; but when the amount of manganese vaporised begins to diminish, its spectrum will gradually decrease in brightness until it disappears. Now, if the disappearance of the manganese lines in the Bessemer spectrum is owing to the diminution of the quantity of manganese, we should infer that these lines would gradually grow more indistinct and then fade away; but, on the contrary, the manganese spectrum increases in brilliancy from its first appearance, and is more intense just before being swept away than at any other time. The analysis of the smoke, which appears when the flame ceases, proves that a considerable quantity is still volatilised, and it is notable that in manganiferous iron this quantity increases towards the close of the blow. 2nd. It would be more difficult to account by this theory for the non-appearance of the sodium line at the beginning of the blow, as sodium then in all probability exists in the issuing gas in sufficient quantity to produce its spectrum at a high temperature, as it is only by special precaution that we can keep it out from any flame. 3rd. A still greater difficulty would arise in applying this theory to the spectra of sodium and lithium at the close of the blow. As has before been stated, these lines sometimes disappear at the moment of complete decarbonisation, and sometimes remain. In the former case, to say that our friend sodium had given out would be doing great injustice to that element, as it has never given us reason for bringing so grave a charge against it. Dr. Wedding, in attempting to demonstrate that the non-appearance of the manganese lines is owing to the lack of sufficient quantity volatilised to produce its spectrum, makes the following statements:—

From analyses made by Brunner we find that the manganese contained in the iron falls from 3·460 per cent. in the raw material, to 1·645, 0·429, and finally to 0·113 per cent. in the decarbonised product; and that the protoxide of manganese in the slag first increases from 37·00 per cent, to 37·90 per cent., and then sinks to 32·23 per cent., and furthermore, that a certain quantity of manganese is to be found in the smoke. How much manganese is really lost by volatilisation cannot be determined, since data are wanting as to the absolute quantity of slag and iron; consequently we cannot determine how much manganese has been lost by means of the eruptions.

But since the manganese contained in the pig-iron decreases constantly, and that contained in the slag after the termination of the boiling period

also decreases, a considerable volatilisation of this body is probable just at the time when the spectrum is best developed. Comparing with this the experiments that can be made in the laboratory we arrive at the hypothesis, that the oxidised manganese which has entered into the slag is not volatilised but is retained by the slag; it can, therefore, get into the flame only in the shape of solid or fluid combinations.

In the above statements the results of the analysis prove that some of the manganese in the slag is volatilised. We cannot consider the manganese spectrum during the entire process as due wholly to the volatilisation of the manganese directly from the iron, for while the amount eliminated from the iron grows continually less, the manganese spectrum grows brighter. Owing to the intimate mixture by the blast of the iron and slag, the manganese oxide contained in the latter is brought in contact with the melted iron and vaporised. This mixing of the slag and iron would cease at the termination of the process, and this would account for the sudden diminution of smoke.

If there was a sufficient carbonic oxide flame to render the escaping gases glowing it is evident they would not issue from the converter as dark smoke, but as incandescent vapour having its characteristic spectrum. The lack of sufficient flame may, therefore, account for the disappearance of the manganese spectrum. The Bessemer flame presents other problems, and opens an intensely interesting field for scientific investigation; and by the use of more delicate instruments than have yet been employed for this purpose, discoveries may be made which will throw new light upon the subject of spectrum analysis.—*American Journal of Science.*

INSTITUTION OF CIVIL ENGINEERS.

AN ACCOUNT OF FLOATING DOCKS, MORE ESPECIALLY OF THOSE AT CARTAGENA AND AT FERROL.

By Mr. George Banks Rennie, M. Inst. C.E.

After touching upon the various modes formerly adopted of cleaning and repairing the bottoms of ships, the author referred more particularly to the wooden floating docks introduced by Mr. Gilbert in the United States of America, and to that made by him, in 1858, at Venice, for the Austrian Naval Arsenal of Pola, in which the two largest ships that had been docked were the *Kaiser*, of 3,225 tons, and the *Ferdinand Max*, iron-clad, of 3,066 tons. The Messrs. Rennie having been called upon by the Spanish Government, to make a proposition for furnishing a Floating Dock for Cartagena, capable of raising the class of iron-clad ships then about to be added to the Spanish Navy, having a weight of from 5,000 tons to 6,000 tons, which represented the *Numancia* and the *Vittoria* types, they proposed a dock somewhat similar to that constructed at Venice, but of iron instead of wood, with certain important modifications. In the wooden structure, in order to sink the dock sufficiently, it was not only necessary to allow water to run into the lower chambers, but water had to be forced into the top compartments at the sides, to overcome the buoyancy of the material; while in the iron structure provision had to be made to prevent the dock sinking when the lower chambers were filled with water. To accomplish this, the upper part of the side walls was divided into compartments, forming permanent air-chambers, or floats, of a capacity sufficient to maintain the decks of the side walls from 6ft. to 8ft. above the water level. The author laid stress on the importance of these for the safety of iron floating docks. As an instance of the success of the Cartagena Dock, he mentioned that the *Numancia*, of 5,600 tons weight, had been supported on it for a period of eighty days. A list was then given of wood and iron floating docks which had come under the author's notice, all of which were of rectangular shaped sections, with the exception of the *Bermuda*, which was of a U section. This latter form required gates, or caissons, to close in the ends, which were not necessary in the rectangular section on account of the bottom and the keel of the ship being entirely raised out of the water. Less water had also to be discharged with the rectangular form, and the amount of pumping varied as the weight of the ship, whilst in the other, or U form, the smaller the ship the larger the volume of water to be discharged. The depth of the basement, or lifting chamber, of a floating dock, like that at Cartagena, mainly depended on the lifting power required. The thickness of the plates of the shell was ⅝in. and 1¼in. in the centre part. For such a vessel as the *Numancia*, weighing 5,600 tons, the strain was estimated to be 1·32 ton per square inch, and for a vessel weighing 20 tons per lineal foot 1·5 ton per square inch.

Of the different plans of conveying docks to their destination, it was remarked that—that of Pola was built at and towed from Venice, that of Havannah from New Orleans, that of Alexandria from France, and the *Bermuda* from the Thames; while those of Cartagena, Ferrol, &c., were sent out in pieces and erected at the respective ports.

The necessary repairs, painting, or cleaning, might be performed by careening, beaching where there was sufficient rise and fall of tide, raising the submerged part out of water by pontoons, or by floating the dock into a shallow basin; this latter plan being the one adopted at Cartagena. The dock at Cartagena was 324ft. in length, 105ft. in breadth, and 48ft. in height outside; these dimensions of the dock at Ferrol were 350ft., 105ft. and 50ft. respectively. After giving a detailed account of the number of chambers into which the docks were divided, and the scantlings of the materials employed in their construction, the pumping machinery was described, and it was stated that it had been designed so as to be as much concentrated as possible, and thus be capable of being placed under the control of one man. The arrangement adopted was that of a pair of horizontal engines, working two pairs of lift pumps, to draw water from a common pipe, communicating with all the chambers. On the ends of these pipes were fixed the inlet sluices for filling the chambers, and on the sides smaller sluices and pipes in communication with each chamber, so that by opening all the sluices the chambers were filled, and on shutting the inlet sluices one or any number of chambers might be discharged. Thus the whole engine power might be employed in pumping out any one compartment, if it was found desirable to do so, in order to balance or level the deck. A detailed description of the engines, pumps, and sluices was then given. The shallow basin, or dock receiver, with its three lines of ways, or slips, occupied the site of some old timber ponds. The basin was of a uniform depth of 16ft. 6in. from the top of the quay wall, and the depth of water was 12ft. 3in. The entrance was 126ft. wide. The basin was 382ft. long on the north side, and 345ft. on the south side. The end was curved, the chord of which was 200ft. From this end ran three lines of horizontal ways, or slips, radiating to a centre. Each was 725ft. long and 45ft. broad, and each was laid with four lines of timber ways, intended to receive vessels after they had been raised by the floating dock. It was estimated that six vessels might be building, or be under repair, at the same time, besides one on the floating dock. The foundations and masonry work were then described, and it was mentioned that the caisson for closing the entrance of the basin was similar to that made by the Messrs. Rennie for Pola. After the basin and dock were completed, water was let into the receiving basin, when the draught of water of the dock was found to be 4ft. 7in., giving a displacement of 4,400 tons as the weight of the dock complete. The dock was afterwards taken into the arsenal basin, and lifted vessels of various sizes—the iron-clad *Numancia* being the largest. The draught of water of the dock with the *Numancia* was found to be 11ft. 3in., the dimensions of the ship being, length between the perpendiculars 316ft, extreme beam 57ft., and displacement at the load draught 7,420 tons. The operation in docking this and other vessels had proved the dock to be in every way efficient, and from the arrangement of the distributing valves, it could be managed with facility, either in sinking or in lifting. The *personnel* of the dock consisted of one chief engineer, one master boiler maker, and with other assistants amounted to eighteen men in all, and with this staff everything went on regularly and without trouble.

ON THE STRENGTH OF LOCK GATES.

By Mr. Walter R. Browne, Assoc. Inst. C.E.

The author first alluded to previous communications on the same subject by Mr. Peter Barlow and by Mr. Kingsbury, in the proceedings of the Institution, and remarked that Mr. Kingsbury, in arguing in favour of cylindrical gates, (*i. e.* such as when closed formed a single arc) had assumed the pressure on such gates to be uniform throughout the section, which was not necessarily the case. The external forces, common to all varieties of gates, were then obtained by the ordinary principles of geometrical mechanics. The most important and complicated case, that of a cambered iron-plate girder was next taken, and it was shown by analysis how to find the strains, and consequently the area requisite at any part, first of the central section, and subsequently of any other section of the gate. The result was an equation between five variable quantities, so that four of these being fixed by other considerations the fifth could be thus determined. These quantities were the two flanges of the girder, the depth and thickness of the web, and the camber. The application of the result to the ends of the gate showed that the area of the front flange (or that away from the water) and of the wed should be greater at the ends of the gate than at the middle. The question was next considered how these other quantities should be fixed. The dimensions of the web and front flange were left for practical considerations. It was shown how for a given pair of gates, to determine the camber, so that the back flange (that towards the water) should be as small as possible. Lastly the proper value for the rise, or sally, of a pair of gates was considered. It was shown that, theoretically, the rise should be such that the gates met at a right angle,

but that there were practical objections to this, which seemed to reduce the proper angle between the gate and the span to from 25 deg. to 30 deg.

The paper closed by remarking that the double skinned gates, now in favour, were heavier than appeared by theory to be necessary; that wooden gates were short-lived and conld not be given much camber, and that a wooden skin, supported by girders at intervals, wonld appear to be the form best adapted to the requirements of theory and practice.

At the meeting of this Society on Tuesday the 10th ult., Mr. Cnbitt, Vice-President, in the chair, five Candidates were balloted for and declared to be duly elected, inclnding two members, viz.: Mr. James Edward Day, Melbourne, Australia; and Mr. Francis Jones, Ex. Eng. for Irrigation, Guzerat. Three gentlemen were elected Associates, viz.: Lieut.-Col. George Chesney, R.E., President of the (new) Indian Civil Engineering College; Mr. John William Inglis, Ex. Eng., P.W.D., British Burmah; and Mr. Charles Marshall Poole, Notting Hill. It was also announced that the Council had recently admitted the following Candidates as Stndents of the Institution, viz.: Messrs. Henry Charles Baggallay, Crawford Peter Barlow, Frederick Stuart Courtney, Thomas Duerdin, Charles Elwin, George Charles Gilmore, Arthur Charles Gotto, Richard Hamilton, William Edward Horn, Joseph Tintorer, and Frederick Thomas Young.

At the close of 1870 the numbers of the several classes belonging to the Institution were: 16 Honorary Members, 709 Members, 1,010 Associates, and 201 Stndents, together 1,936, as against 1,802 at the same date last year, showing an increase at the rate of 7½ per cent. in the twelve months.

ROYAL GEOGRAPHICAL SOCIETY.

ON THE GIBRALTAR CURRENT, THE GULF STREAM, AND THE GENERAL OCEANIC CIRCULATION.

By Dr. W. B. Carpenter, F.R.S.

The anthor commenced by an allusion to the investigations carried out for three years past, with the aid of the Hydrographic Department of the Admiralty, into the nature of the deep sea, and detailed the observations conducted by himself and Commander Calver of H.M.S. *Porcupine*, on the outflowing undercurrent at the Straits of Gibraltar. He showed on what insufficient observations the snpposition of a current flowing outward from the Mediterranean had hitherto rested. An outflow of this nature was a necessary hypothesis: for the excess of saltness caused by the great surface-evaporation (naturally of pnre water only) from the Mediterranean wonld otherwise be most sensibly felt in the waters of that sea; and this was not compensated by rainfall and rivers, or by the water flowing in to restore the level, which consisted of Atlantic salt water setting inwards, in a surface-stream, at the rate of three miles an hour. It was singular that the shallowest part of the Straits was not where they were narrowest at Gibraltar, but mnch farther to the west, between Capes Trafalgar and Spartel; the sea-bottom slopes westward from Gibraltar, where it averages about 400 fathoms, to the western extremity, where the depth is scarcely 50 fathoms on the northern, and 200 fathoms on the southern half. After repeated observations, aided by the ingenious mechanical contrivances of Commander Calver, the existence of a deep-water current setting outwards was finally established. It was true the stream must thus be supposed to flow up-hill along the sea-bottom from Gibraltar to the shallow ridge westward (the true limit of the Mediterranean basin); bnt this was shown to be the natural action of flowing water under snch circumstances. Dr. Carpenter then explained that this interchange of water between the Mediterranean and the Atlantic was in accordance with a simple physical law, and that the same law, in its wider application, threw a new light on oceanic circulation and marine currents throughout the globe. As the surface water of the superheated Mediterranean ascended by evaporation, leaving its saline constituents behind, the remaining water, becoming denser and heavier by its increased saltness, sinks beneath the less salt Atlantic water flowing inward by the Straits, and is eventually forced outward as an under-current, as proved by the recent observations. If the accession of fresh water by rain and rivers in the Mediterranean had equalled the amonnt evaporated from the surface, instead of being much the reverse, there would have been no current and counter-cnrrent at the Straits of Gibraltar; and if the fresh-water supplies had been greater than the evaporation, there would have been a surface-current outwards of the lighter water. This last hypothetical condition is precisely that of the Baltic in regard to the North Sea, in which case there is a surface-flow of fresh water outwards and an under current of heavier sea-water inwards. It was obvious that a like circulation of waters, the lighter above and the heavier below, in opposite streams) must take place in any case in which a want of equilibrium between two columns of water is constantly maintained, whatever might be the agency producing it. A great difference of temperature at two extremities of a great ocean must cause two such currents to be set going on a vast scale; for, as in the cold area, water contracts and becomes heavier by the cold, its level must sink, and the general oceanic level be continually maintained by a flow of warmer and lighter water from the warmer areas of the same or adjoining ocean. The recent investigations had snpplied resnlts in accordance with this hypothesis. Such circulation of oceanic water being universal, Dr. Carpenter had found reason to doubt the received opinion of the Gulf Stream being the direct cause of the set of warmer water towards North-Western Europe and into the Arctic circle; the Gulf Stream was rather a local accident of the oceanic circulation, resulting from configuration of the land past which it flowed, and its existance as a stream mnch beyond the banks of Newfoundland was not proved. A beantifnl experimental illustration of opposite currents was exhibited by the author. At the extremities of a long glass trough, filled with water, upright tubes were fixed; one of which was filled with ice, and the tube at the opposite end heated by a gas jet. On blue colouring matter being inserted at the cold, and red at the warm end, the two separate streams became visible, the red near the surface and the blue below.

THE LONDON ASSOCIATION OF FOREMEN ENGINEERS.

ANNUAL GENERAL MEETING.

The eighteenth annual meeting of members of this institution was held on Saturday, the 7th ult., at the City Terminns Hotel. There was a very numerous body of associated foremen present on the occasion, and mnch interest was manifested in the proceedings. Soon after eight o'clock the chair was taken by Mr. Newton (Royal Mint), and the business of the sitting commenced with the election of new members. Mr. Coates and Mr. Guthrie were unanimously voted in as associates of the ordinary class.

The anditors, Messrs. Ives and Gibbon, next produced the balance sheet and their report for the past half-year. These documents were both of an eminently gratifying nature, and proved that the society is at present in a far more prosperous condition than ever, in all ways. The actual number of members connected with it is 112 of the ordinary class (principal foremen, and principal mechanical draughtsmen) and 75 of the honorary rank (engineering employers and other scientific gentlemen)—making a total of 187. The general fund of the association amonnts to £516 3s. 4d.; the superannuation fund (for infirm and necessitous members), to £1,072 8s., and the widows' and orphans' fund to £18 12s., in all £1,607 3s. 4d. The expenditure of the half-year for the assistance of unemployed members reached only £8, whilst the subscriptions of those in full employment to the general fund of the institution during the same period amounted to ten times that sum. In fact, a sensible improvement was manifest in every financial department of the society. After some slight discussion of a congratulatory nature the report and balance sheet were accepted *nem. con.* by the meeting.

Mr. Newton then proceeded to deliver the annual presidential address. Unfortunately this was far too lengthy to be reproduced in our columns, although it embraced topics of considerable interest to the mechanical community generally, as well as to the particular audience for whom it was principally intended. We can only refer to some of the points included in Mr. Newton's elaborate retrospective and prospective statement. The speaker, after a few introductory observations, gave a biographical sketch of the late Mr. William Henry Keyte, one of the founders of the association, and whose death had taken place since the previous annual meeting. This was interesting as a record of the vicissitudes in the life of one who might be termed a model foremen of engineers. Mr. Keyte had passed through all the stages which usually chequer the progress of men of the same class. Ripening from the apprentice into the journeyman, he had become next outdoor foreman, then indoor foreman of a department, next general foreman, and finally manager. In the latter capacity he was in the employment of Messrs. Shears and Sons, of Bankside, at the time of his decease. Many particulars were furnished relating to the late member and his onward and upward career. An idea of his general character and qualifications may be gathered from the concluding paragraph of the biographical sketch given of him by Mr. Newton. "Mr. Keyte so comported himself at all times as to gain the esteem of those under whom he served, and of those who served under him. These ends were realised, not by slavish subserviency on the one hand, or by undue favour on the other, but by a

manly and enlightened determination to do his very best for the interests of his employers, and by always manifesting a fair consideration for the welfare of the workmen be controlled. Such an example was worthy the imitation of all foremen, and of all intermediate agents between masters and men. Mr. Keyte was talented, truthful, and generous. His death was, therefore, a misfortune for the association which he had assisted to create, and of which he had always been an active and zealous member." Mr. Newton next proceeded to review the year's progress as regarded the working of the society; he congratulated his fellow members on its increased numerical and financial strength, and on the augmentation of dignity to the position of foremen which its scientific transactions induced; spoke of the necessity for the yet more complete understanding between employer and employed; referred to the terrible and unnecessary war now being waged in France, and expressed a hope that if Great Britain should unhappily be by and by involved in hostilities our Government would not be found unprepared to face the crisis. In all future wars engineers must play an important part, and for himself he (Mr. Newton) felt assured that foremen would not be found wanting in patriotism should an enemy put them to the test, whether the name of the foe were Bismarck or Gortschakoff.

Reverting to what might be termed the domestic department of the institution, the chairman appealed passionately to the members to increase the fund for the solace of widows and orphans. At present the amount was quite unworthy of them, and really was nothing more than a funeral subscription. He should not be content until the treasurer was in a condition to pay over £100 instead of £20 to each widow or family of a deceased member.

In conclusion, Mr. Newton thanked the members of the association for their uniform kindness to himself and for the extreme confidence which their re-election of him at twelve annual meetings previously to that evinced. He begged hard to be released from official duty thenceforth, and in accordance with the rules of the institution, resigned the post of president and vacated the chair.

Almost immediately afterwards, and on the nomination of Messrs. Hosken and Briggs, the two oldest members, Mr. Newton, in spite of his strong protestations, was unanimously re-elected president, Mr. J. Irvine was subsequently chosen as vice-president, Messrs.. Phillips and Welsh were appointed auditors for the current year, and Messrs. Hedley, Ronald, and Jordan were elected junior committee men. Soon afterwards the proceedings, which throughout were marked by a cordial and harmonious course of action, terminated. The anniversary festival of the association is to take place on Saturday the 18th inst. at the City Terminus Hotel.

INSTITUTION OF ENGINEERS IN SCOTLAND.

ON THE EDUCATION OF THE MINING ENGINEER.

By John Young, M.D., F.G.S., F.R.S.E., Professor of Natural History in the University of Glasgow.

To commence an address to such an association as now honours me by listening with the definition of a Mining Engineer, may be to secure that precise understanding which logicians insist on; but to most it will seem a work of supererogation. Yet I question if, habitually as the phrase is used, there are any here who have ever asked themselves, What are the limits of the duties of the mining engineer? and I do not question, I am certain, that not one has endeavoured to ascertain how any one assuming the title has qualified himself to do so. I speak thus confidently, because it seems to me a matter of certainty that, had British engineers ever fairly faced the inquiry into the rights of men to assume the name of "Engineer," some measures would have been taken to protect the title—not by trying to limit the number of holders, but by granting it to as many as proved themselves qualified for the responsible duties of the profession. But of this again.

A mining engineer is one to whom is credited sufficient knowledge of the conditions under which minerals occur in the earth to render him a reliable adviser in the search after them: who is believed to know the qualities of minerals so as to decide on the worth of any that may be found, and who, these points having been satisfactorily decided, possesses sufficient mechanical skill to conduct all the operations connected with the extraction of the mineral from the earth. He who merits the comprehensive title of mining engineer should be a geologist and mineralogist as well as a civil engineer. In this sense—and it is the only rational one—there are *very* few mining engineers in Scotland. This is no reflection on the existing representatives of the order. It is much to be regretted that there are so few facilities for their position being rectified; but so long as the educational opportunities are so defective—so long as there is no body whose interest it is or might be made to insist on a certain amount of instruction—there is no use blinking the fact that mining engineers are unqualified in the sense that our advocates, medical men, and clergy are qualified.

Now, before urging any change one or two questions have to be answered. Those who are most deeply and directly interested in the efficiency of the mining engineer are the proprietors of mineral wealth. Are they content with things as they are? Do they believe that the men whom they presently employ, on whom they rely, are deserving of that confidence? While admitting that there are many men of superior ability or large experience who are admirably successful in the majority of their operations, there is no question that as a whole the mineral resources of this country are not administered with that economy so important in dealing with supplies which by their very nature are terminable, whose exhaustion is a certainty though the date may be open to controversy. The evidence in support of my statement it is difficult to give. It is to be found in the censures incidentally dropped by inspectors of mines, and by the better informed iron-masters. But few whom I now address are ignorant of examples, whose number, considering their limited experience, suggests the frequency with which gross blunders are perpetrated. I might cite many cases which might be amusing did they not tell of disappointed hopes and loss, even ruin, to those who put their faith in the so-called practical men. But I may be allowed to refer to a few which stop short of the tragic. It is well known that bores have been sunk from one side to the other of faults whose existence was revealed in adjacent but unvisited brooks, the bore being put down at great cost into beds far below the valuable stratum sought for. An eminent engineer has counselled the lease and working of a property which contained beds lying immediately above the coals sought for, in ignorance of the fact that there was an extensive overlap or unconformity by which the productive seams were thrown out, and the property therefore valueless. As a converse, some years ago an engineer, having seen the results of borings, accepted these as evidence, and counselled his client to his ruin, it never having occurred to him to test the authenticity of the specimens submitted, or to compare them with the geological facts revealed by sections in the vicinity. But why multiply what are in reality bits of gossip, in so far as they deal only with particular cases. The existence of the "mystery-men," the borers, as a class is itself evidence of a defect somewhere. These men should be the servants of an instructed engineer. In reality they are masters by virtue not merely of their mechanical dexterity but of the tradition of their local knowledge. Great as are my obligations to some members of this class, truth compels me to add that the boring machine exhibited at your congress in August—a machine which withdrew a cylinder of rock—was to my mind a powerful educational engine, since it would certainly curtail the supremacy of the borer and impose more direct responsibility on the engineer. The notorious frauds of unworthy members of the one class would be prevented, and the ignorance of the other class would be deprived of the protection from responsibility which the opinion of pseudo-experts has hitherto afforded them. I have been told that men who have given their lives to one district are more likely to know that district better than a stranger, an argument which would prove a mole a good geographer because eminently careful in local research—an argument which, to be valid, requires proof that the local worker has something more than mere rule-of-thumb knowledge. It is a curious commentary on this doctrine that the most strenuous advocate of the superiority of local men is the wealthy employer who trusts his capital to a manager of life-long experience, but of such slender knowledge that he thought hœmatite contained 90 per cent. of iron! It is not the M'Clarty philosophy of doing well enough which ought to suffice. It is the best possible which ought to be secured; and though this may involve a little pecuniary sacrifice, it is not the less a duty to our successors to act, not as the life-tenant of an entailed estate who has quarrelled with his successor and spoils it as far as may be, but to act as the conscientious trustee who shall hand over his trust benefited as far as may be. Nor is the sacrifice of money likely to be so great. Properly administered, skilled labour is the cheapest. Selfishness requires for present benefit a line of conduct which shall at the same time fulfil the higher moral obligations just alluded to.

Motives of personal interest, therefore, seem to justify the insistence by mineral proprietors on some organised scheme for the instruction of the men on whose advice they rely.

But the profession of engineers has a duty in the matter. At present any man can call himself an engineer, and a mining engineer may be defined in practice as a man whom chance has brought into frequent contact with mineral proprietors. Reverting to what I have already said concerning the functions of a mining engineer, I appeal without hesitation to this audience for an emphatic declaration that such a state of things should not exist. Your reputation as a profession is at stake. Your relations to the public are not defined. Is it wise to leave the public in absolute uncertainty as to the character and qualifications of

those whom they wish to employ? If it is contemplated to procure a charter for your Institution, that charter ought to include a class of men whose special knowledge is worthless, even if they possess it, unless it is combined with the thorough equipment of the civil engineer. But apart from the injury to your own profession wrought by the unchecked multiplication of tradesmen who assume the same style as the accomplished scientific men among your number, your voluntary association imposes on you a duty which, to my mind, is of paramount importance. It is inept to say that the public will soon recognise the difference between the good and the bad. It is not even true; for we know that many quacks retain a position forfeited by their ignorance and blnnders, but secured by their impudence. And even if it were true, is it right? Every such experiment made by the public involves loss. To throw on the public the dnty of thus testing professional men is to tax them very heavily, as if people were to select their medical men by trial, that trial involving many deaths.

It is for the profession to consider the amount of its obligations, to determine whether it is to consist of so many nnits, each competing with his neighbours and anticipating his fate by the uncertain operations of the law of natural selection; or is to form itself into an instructed court qualified and courageous enongh to decide who are or are not entitled to public confidence.

Assuming it as admitted that intuition alone does not fit a man for the duties of a mining engineer, and that merely local experience does not place him above the level of an underground viewer, what training is best fitted to impart the necessary knowledge in the shortest time? It is further necessary for me to assume that the Institntion of Engineers recognises a duty as well as expediency in procuring, if it does not already possess, powers to certify the qualified in this particular branch of the profession. Only three courses are open:—1st, to certify upon examination any one who desires to be tested; 2nd, to impose certain conditions as regards study upon all who seek examination; 3rd, to establish a school or college, or to obtain paramount influence in some such establishment already existing, in which the necessary training preliminary to examination may be obtained.

This last mode of meeting the difficulty I shall discuss first. It seems to me a cause of satisfaction that at present there is no prospect of any such attempt being made. Any new school could only, as things now stand, injure existing schools or colleges without securing its own end. There is not money to be had sufficient to start a scheme which wonld not injnre them. It would require £3,000 a year as a modest minimum to secure the teaching of the higher branches, and where is the preliminary training to be got? Either by opening preliminary schools, or by insisting on an entrance examination, which would for some years keep the college empty, till the schools responded to the stimulns, and that would only be if the engineers counterbalanced in profit the payment by resnlts which at present holds the schoolmaster's nose to the department grindstone. Obviously the scheme would be too extensive both in scale and cost. But I do not despair of the day when it may be realised. There are many snbjects not yet included in the university curriculum which are nevertheless capable of theoretical discnssion, as mining, metallurgy. The time will come when these shall be included. Thereafter the co-operation of several professions and trades will render possible the formation of what, for lack of a better phrase, may be called a technical school, one, that is to say, in which instruction will be given, not in theory, but in the application of theory to practice. Thus practical chemistry, geological field-work—in other words, the art of mapping a country—will find a place, not as superseding, but completing the higher instruction. To the practical laboratories would come those engaged in textile manufactures as well as engineers. But this is looking farther forward, perhaps, than many of my hearers think advisable. Let me return, therefore, to the first of the plans proposed—that of a professional examining board granting certificates, on examination, to all who choose to come before it.

Theoretically I have no objection to the existence of such a board independent of a university. In fact, in the case of the medical profession, I have recently urged its creation by government, on the ground that a perfectly impartial and independent court of examination in practical subjects would give a secnrity not to be obtained under our present system. A similar court controlling the admission of engineers to the professiou would be a most desirable innovation. Of course, the co-operation of members of tho profession throughout the country would be necessary, but that co-operation does not seem difficult to obtain. The Institution of Civil Engineers in London has a body of laws which has secured such general approbation that tho regulations of local institutions are only suitably modified copies. Our friends from the North of England, and those in the West of England, represent considerable areas and large interests, while the mode in which they have testified their sympathy and goodwill is an assurance that their aid will not be hard to obtain in furthering any scheme having the general good in view. Nor is there any difficulty in procuring examiners. The profession contains very many who are well qnalified to judge on the knowledge and skill of candidates, and snch men, of high attainments, are sufficiently distributed through the country to give good prospect of that uniformity of standard so needful when the same honour is to be awarded in all districts. The association with the court of teachers— be they professors or other—is a detail only to be settled after the subjects have been determined in which candidates are to be tried. But in no case should any assessor be elected save on the ground of demonstrated practical skill in addition to theoretical attainments. Let us suppose the court agreed on. On what conditions may candidates present themselves? They must be men who have either gone through an organised course of study, or who have prepared themselves for examination, when, where, and how, it seemed best to themselves. The latter is free trade in edncation, of which I have elsewhere avowed my theoretical approval, though in practice it onght to be condemned as concealing a mischievous fallacy. In one or two subjects it is possible a student may learn thoroughly by his own efforts, but in the majority, more especially when equal knowledge of all is needed, snch private study mnst fail, save after an expenditure of time which would in effect make the profession the monopoly of the wealthy. The system of apprenticeship will of course be appealed to: it is a very important edncational agent or method, but in objecting to the extreme valne which many are disposed to attach to it, there is precedent in the medical profession. It is a useful auxiliary of, it is an admirable sequel to connected systematic study. But because it is of necessity unsystematic, it cannot be held as superseding organised courses of instruction. Time was when to have sat at the feet of some Gamaliel of itself conferred distinction and inspired confidence, but that time passed away as science became more extensive and precise: it was an admirable way of acquiring practice, but it is not the way to learn principles. The retention of the apprenticeship system is indispensable, but its place in the scheme of study requires still to be fixed.

Objecting as I do to free trade, it remains for me to state the course of stndy which the imagined court should impose. Several universities have laid down curricula for the civil engineer, and confer certificates or degrees on its satisfactory completion. I am so recently a member of the engineering department in Glasgow University, that it is permissible for me to refer to Professor Rankine's efforts, and to congratulate him on the public recognition which has to some extent, and which will, still more emphatically, reward his exertions. Far be it from me to snggest any interference with that or other schemes. On the contrary, it is in the power of the Professor to aid in giving them still more importance by making the degree or certificate a prerequisite to examination for admission into the chartered body. It would follow of necessity that the court would not go over the ground covered by the universities or colleges presently in operation. Their work would be the application of tests which would show incidentally the possession of ample theoretical knowledge, but which would have as their primary object to prove the possession of practical skill, the power to apply theory to actnal work. This, however, deals more with the civil engineer, as the term is commonly understood. For the mining engineer no such course is as yet prescribed. I might refer to the conduct of Sweden and of France in this matter as justifying my insistence on some addition being made to the ordinary engineering course; but it will be sufficient to speak of the mining school in Jermyn-street, the only one which has survived in this country. It is now two years since this qnestion was discussed in the "Daily Mail," and the description there published may be quoted:—

"Thirty-six years ago Sir (then Mr.) Henry De la Beche began the geological survey of England as a private enterprise. After some years of labour tho recognition of Government was secured for the undertaking, and was richly earned by the success with which the survey had been conducted, and tho promise of important economic results which its extension held out. In 1851 the bnilding in Jermyn-street was completed by Sir R. Peel's Government, and became an edncational establishment of the highest importance to the miner and metallurgist at home and in the colonies. Tho building contains the offices of the Geological Survey and of the Keeper of Mining Records; the Museum of Survey, mineralogical and metallurgical specimens; and the class rooms and laboratories of the teachers, except the chemical laboratory, which is in a separate building, tho Royal College of Chemistry, Oxford-street. All these departments are under the control of Sir R. I. Murchison, but interesting as are their history and organisation, I propose to confine attention for tho present to tho Royal School of Mines.

"The staff of tho school consists of the director, Sir R. I. Murchison; and the lecturers—On Chemistry, E. Frankland; Natural History, T. H. Huxley; Physics, Guthrie; Applied Mechanics, R. Willis, M.A.; Metallurgy, J. Percy, M.D.; Mining and Mineralogy, Warrington W.

Smyth, M.A.; Geology, A. C. Ramsay; Mechanical Drawing, J. H. Edgar, M.A. The curriculum is as follows:—

First Year.
For all Divisions.

1st Term, Oct.—Feb.	2nd Term, Feb.—June.
Inorganic Chemistry with Laboratory Practice.	Physics.
Mechanical Drawing.	Laboratory Practice.

Second Year.
For all Divisions.

Mineralogy.	Geology.
Mechanical Drawing,	

Third Year.
A. Mining Division.

Mining.	Applied Mechanics.
Assaying.	

B. Metallurgical Division.

Metallurgy with Laboratory Practice.	Applied Mechanics.
	Metallurgical Practice.

C. Geological Division.

Natural History and Palæontology.	Palæontological Demonstrations.

"The studies of the first two years are compulsory on the candidates for the associateship, but 'in the third year the candidate may confine himself to the Mining, Metallurgical, or Geological Divisions, and pass his examination in the first class of one of these divisions only.' Whatever division, therefore, a student may select with a view to his future career, his proficiency in that division is based on a sound knowledge of those subjects without which the practical miner, metallurgist, and geologist may, indeed, be a good tradesman, but cannot be a man of science. The fee for students desirous of becoming associates is £30 on entrance, or two annual payments of £20. but this admits only to the lectures; the fees of the Metallurgical Laboratory are £15 per term of three months; for the Chemical Laboratory, £12 for the same period.

"Certain endowments are connected with the school, namely, three sets of prizes, and fifteen bursaries from £15 to £50 each, the latter (three in number) tenable for three years. Few schools are so richly endowed; in few have the highest honours been so sparingly given, the number of associates admitted during 17 years being only 42. An increase is noticeable in the number of candidates—nine obtained the honour in the first five years, 10 in the second, 17 in the third, and six have been added during the last two years. Their certificates are in the following divisions:—

Mining, Metallurgy, Geology,	12
Metallurgy, Geology,	8
Mining, Metallurgy,	4
Mining, Geology,	3
Geology,	10
Metallurgy,	3
Mining,	2

"It is worthy of remark that the majority of the 12 certificates in all these divisions were given in the first five years, and all were prior to 1862. As might be expected, the greatest eminence has been subsequently reached by the first, the most numerous group of proficients in all these divisions. This school was originated, and has succeeded, in spite of the fact that no mining or metallurgical operations are conducted nearer London than Bristol or Gloucester, and that no district within this minimum distance offers opportunities for practical instruction at all to be compared with those which are to be found in the immediate vicinity of Glasgow. It was founded in answer to an appeal made by the leading representatives of the mining interests of Great Britain. But it does not appear that Scotland has as yet benefited largely by the Jermyn-street teaching. It is difficult to give a reason for the absence in Scotland of anything approaching to a mining school. Our mineral properties are, on the whole, as well managed as those of England; in metallurgy neither pains nor cost have been spared in procuring the best advice and practising the best methods. Yet nowhere can any one, proprietor. manager, or miner, obtain any information as to his work save by apprenticeship."

This was written in support of a scheme for the institution of a lectureship on mining. At that time my efforts failed, and my expenditure for two sessions in providing a competent lecturer was thrown away, save n so far as my sincerity in the matter was subjected to the severe test of loss of money. Failure has not however, diminished my hopes. I am sanguine enough to anticipate the erection of Geology into a separate chair as well as the foundation of the Mining Lectureship.

From the passage just quoted it is evident that in Glasgow University (to take the nearest example) all these subjects are taught save mining, assaying, and metallurgy. The Chemical Laboratory might do something were good cause shown in the way of assaying; instruction in mining it would not be difficult to procure, but metallurgy is beyond hope for some time at least, the cost of the laboratory being the chief obstacle. For the present, therefore, the court, such as has already been indicated, would have no power to prescribe that full complement of study open to the student in Jermyn-street. But it would be in the meanwhile competent to require proof of skill as acquired during apprenticeship to, or pupilage with a professed mining engineer. This would not accomplish all the desirable good, but it would be a step in the right direction, and those who wished and who could afford it might repair to Jermyn-street for what they could not get here.

To the appeal for means to establish a mining lectureship the frequent answer was that those at present employed are good enough without further instruction. When the possibility of skilled men introducing new methods was suggested, something like a devout prayer was breathed that such a possibility might never be realised. It happened that the lessons which had taught this wholesome fear of forsaking the customs of their forefathers had been taught by not skilled men but essentially unskilled men. In the West of England at present there is at least one striking example of which you are probably aware, where a highly trained pupil of Jermyn Street has, amid derision and sympathetic hope for his ruin on the part of those who have been all their lives working in the district, followed his own way and realised a fortune, because, as a geologist, he knew that a hill capped with trap was not a hill of trap, though several largely employed engineers and experienced managers were prepared to swear to the contrary.

It is perhaps a better key to my failure that the proposal was made with a view to the connection of the lectureship with a university. University training it was more than once said did not make men more fit for business, rather the reverse—a courageous statement, since at the time the sons of those who said so were attending university classes. But as an example of what scientific training may do, let me refer to the work of Mr. Hull, now the Director of the Geological Survey in Ireland. When engaged in the survey of an important English coal-field, evidence was lost at one point as to the lie of the seams. Trusting to the information yielded by the other strata, he mapped the country, indicating conjecturally the position of the coal seam, showing, that is to say, where it would have been had its course been normal. He further prepared, as was customary, a section of the country, and gave the depths from the surface at which, barring subterranean contingencies, the coal would be. Acting on these statements, a proprietor sank at two miles from the last proved point and found the coal a fathom nearer the surface than Mr. Hull with commendable prudence had said. I question if all the mining engineers and managers put together would do as much here. And no discredit to them; they have never been taught the art of field-mapping, the application of geological science.

I appeal to the profession of engineers to step in and protect their own profession. If the time has not yet come for them to acquire the organisation which has done so much for Medicine and Law, it is at least in the power of individual members to enjoin on their pupils and the younger members the duty of paying some attention to those matters on which they may be called upon hereafter to give responsible opinions.

In this direction much good might be done by the intervention of such an Institution as this in behalf of the introduction into schools of such teaching as would assimilate some of them to the higher primary schools in France. Mere Chemistry, Physics, and Geology might be got in at the cost of fruitless time spent on subjects, profitless in themselves or because of total inaptitude for them on the part of the learner. Not only might the time of the student be thereby economised, his stay at college being proportionally curtailed, but science would be benefited, because the university teacher would be spared the drudgery of elementary instruction, and enabled to apply his thoughts to the cultivation of the higher branches of his sciences.

But what it has been my purpose to insist on more paricularly is that the engineers of this country have attained a numerical strength and a position, both socially and in science, which justifies them in securing privileges similar to those now held by other professions. And the first use to which the possession of those privileges might be advantageously turned is the assertion of the right to declare on what conditions membership may be obtained. The control of professional education is one of the first duties, were it for no other reason than to stop the curious absurdity of its being legitimate for any man to put C.E. after his name, allowing the ignorant to believe him qualified, and to learn the truth only after they have been ruined. Many members of your Institution have told me amusing results of this extraordinary procedure, without parallel in any other profession, requiring for its exercise equally

great scientific attainments. But I am not competent to judge of civil engineers. Of mining engineers I have had opportunities of knowing something, and in the strength of that knowledge I urge the attempt to provide better educational opportunities for them than now exist, and the duty of insisting that the title be assumed on some better ground than accident or caprice.

The Court of Examiners, whose position and powers could only be secured by Act of Parliament, would find its highest reward in confining its attention to the practical testing of candidates, leaving the schools and colleges unfettered as to the conditions on which they may grant their certificates or diplomas. Free competition between the schools would soon secure a high standard of teaching, and especially if the results of their work were to be reviewed by an independent court of examiners. But to secure this benefit the certificate of a school should be required of every candidate. The certificate of the court of examiners would be, in fact, a license to practice. But let me add a hope that the granting of this license would not close the relation of the examinee to the Institution. The licentiates of the medical colleges have neither part nor lot in those bodies unless they afterwards, at much cost, become fellows. Profiting by their experience, a new corporation would do well to consider whether the examination fee might not be such as to confer membership—actual membership, not a titular relation. So might the Institution become, not a voluntary society, but a brotherhood of common aims, and exercising a mutual influence for good.

Such are the views which I have taken the liberty of bringing before you. For the dogmatic character of several of my statements I would crave pardon, but that my remarks may thereby provoke more unsparing criticism. Such criticism is to me an object of much importance, because my views are common to many members of your profession; and among my medical brethren, the similar views I have elsewhere expressed regarding medicine meet with some sympathy. To impose on independent bodies the task of proving the practical skill of students, thereby to relieve the schools of responsibility in all save the provision of thorough education, and to aid the teachers in discovering the best mode and kind of instruction, these are the aims which many members have set before themselves, and which before many years they will see accomplished. But if their hopes are to be realised, it is necessary that changes may be made with all possible care and deliberation. In advocating change I have unbounded faith in that conservatism which is inherent in all large bodies of men, which protects against rash meddling, and gives security that nothing will be done which has not been proved to be good.

STEAM BOILER LEGISLATION.

An important conference was held on Friday, the 13th ult., on the subject of "Steam Boiler Legislation," under the auspices of the Manchester Steam Users' Association, at their offices, 41, Corporation-street, Manchester.

As this subject is now under the consideration of Parliament, with a view to introduce some measure for the protection of the public from the recurrence of boiler explosions, it becomes one of general interest. The following gentlemen were present at the conference :—Sir William Fairbairn, C.E., F.R.S,, Manchester; Mr. Thomas Hawksley, C.E., London; Mr. Birley, M.P., Manchester; Mr. Hick, M.P., Bolton; Mr. Lancaster, M.P., Wigan; Mr. Anthony Bower, C.E., Liverpool; Mr. John Hocking, C.E., Redruth; Mr. Hugh Mason, Ashton-under-Lyne; Mr. Thomas Schofield. Manchester; Mr. Charles Heaton, Bolton; Mr. Charles F. Beyer, C.E., Gorton; Mr. James Petrie, Rochdale; Mr. Henry R. Greg, Stockport: Mr. Alderman Wright Turner, Pendleton; Mr. Adam Dugdale, Blackburn; Mr. Jabez Johnson, Bolton; Mr. William Richardson, C.E., Oldham; Mr. Lavington E. Fletcher, C.E., Chief Engineer; Mr. Robert Tonge, Secretary. Added to the above, the following gentlemen were invited, but were unavoidably prevented being present:—Sir Thomas Bagley, M.P., Manchester; Mr. Jacob Bright, M.P., Manchester; Mr. Charles Vignoles, C,E., F.R.S., London; Sir William Armstrong, C.E., Newcastle; Mr. John Ramsbottom, C.E., Crewe; Mr. John Penn, C.E., F.R.S., Greenwich; Mr. John Anderson, C.E., Woolwich; Mr. G. F. Lyster, C.E., Liverpool; Sir Joseph Whitworth, C.E., F.R.S., Manchester; Mr. E. J. Reed, late Chief Constructor of the Navy; Mr. Samuel Rigby, Warrington; Mr. James McConnel, Esher; Mr. James Taylor, Wigan; Mr. William Himtriss, Halifax; Mr. James Newlands, C.E., Liverpool; and Mr. William Roberts, Burnley.

After a conference lasting upwards of three hours, Sir William Fairbairn presiding, and such of the members of the select committee on boiler explosions as were present, remaining as listeners without voting, the following resolutions were passed :—

1. "That the use of steam, as at present conducted, entails great suffering from the destruction of life and property occasioned by the constant recurrence of boiler explosions. That boilers are now to be found under the pavements over which the public walk, behind walls close to which they pass, in the basement of buildings crowded with busy workpeople; and that, in short, they are to be found everywhere. That many of such boilers have given rise to the most disastrous explosions, so that the lives of all those living near so dangerous an instrument as a boiler, or even casually passing by, are seriously jeopardised unless suitable precautions are adopted to ascertain whether the boiler be safe and trustworthy, and if not, to render it so. That most of those who have suffered from these explosions have had no voice in the management of the boilers, and thus were helplessly victimised, some being women in their own houses, and others, children at play. Further, that in the generality of cases, those injured by the explosions of boilers at the works at which they earn their livelihood are in a similarly helpless position, and, as a rule, too poor and too ignorant to defend themselves.

That the subject, therefore, becomes one of general and public interest, demanding immediate investigation, more especially since the use of steam is daily on the increase, and, notwithstanding and precautionary measures at present adopted, explosions still recur with the most persistent regularity and frequency."

2. "That boiler explosions are not a necessary consequence of the use of steam, but that they are as a rule preventable. That though complicated in result they are simple in cause; arising, in the main, from bad boilers: bad either in construction, or bad in condition. That six explosions are due to bad boilers through the neglect of the boiler maker or boiler master for every one due to the neglect of the boiler minder. That competent inspection is adequate to detect the badness of the boilers, and thus to prevent by far the greater number of the explosions now occurring."

3. "That notwithstanding the proved efficiency of competent boiler inspection, and the publicity constantly given to the subject, yet that steam users refuse to protect the lives of their workpeople or those residing near to their works, by having their boilers inspected. That it appears approximately that out of about 100,000 boilers in the country, only 20,000 are enrolled either with inspecting associations, or insurance companies, so that out of every five boilers, one only is enrolled. That a great number of boiler owners are totally ignorant of the risk to which they expose their own lives and those around them, and in many cases are only undeceived by the shock of explosion. That, judging from experience, there can be no doubt that there are now a number of dangerous boilers, on the very verge of explosion, being worked on at the risk of all those living near them. That under these circumstances the public safety demands that competent periodical inspection should be enforced by law."

4. "That although it is necessary in the interest of the public that inspection should be enforced by law, it is not advisable either in the interest of the steam user or the public at large that that inspection should be undertaken by the Board of Trade, or any other department of the Imperial Government, as such a course would, it is feared, harass the steam user and hamper progress."

5. "That while the administration of a system of enforced inspection should not be committed to the imperial Government, neither should it be committed to local authorities, nor to private inspecting associations, nor to insurance companies."

6. "To secure the purity of the inspection let the administration be above all local, party, or private interests, and let it be undertaken, not for profit, but to promote the public safety. To prevent the administration becoming arbitrary, stereotyped, and old-fashioned, and to render it capable of adaptation to the constantly altering and growing requirements of the boiler owner, let it be administered by district boards, constituted partly of gentlemen elected by the steam users themselves, and partly of *ex-officio* members to be chosen on behalf of the public, the boards having the power of making such laws, rules and regulations from time to time as might be found necessary for the conduct of the service."

ROAD LOCOMOTIVE.

By Messrs. Robey and Co., of Lincoln.

In our last issue when describing the various objects of interest at the Smithfield Club Show, we mentioned amongst others, the road locomotive exhibited by Messrs. Robey and Co. We are now enabled, through the courtesy of the manufacturers, to give the accompanying illustrations, of this engine, Fig. 1 being a vertical section of the boiler, and Fig. 2 a sectional elevation of the engine, showing the general arrangement of the machinery. The illustrations are so self-explanatory that little description is needed. It will be seen, on reference to Fig. 1. that the boiler is upon the well-known "pot" system, invented by Mr. Thompson, and, in fact, the entire engine is an improved arrangement of that gentleman's

road locomotive. The boiler is composed of steel plates $\frac{3}{8}$in. thick, and is 2ft. $9\frac{1}{2}$in. in diameter, and 7ft. $7\frac{1}{2}$in. high. The fire box which is 2ft. 3in. in diameter, and 3ft. $9\frac{1}{4}$in. high, has a copper "pot" fitted into the crown, and made steam tight by means of metal rings with a washer of india-rubber placed between them; the pressure ot water against the bottom of the pot acting upon the india-rubber, and thus making a perfect joint. This "pot" is 2ft. in diameter with a 9in. neck, and the vertical tubes are $2\frac{1}{4}$in. in diameter, and 3ft. 4in. long. Boilers of this description have been found to be very economical in fuel, but we question whether they are suitable for dirty water.

The engines, as shown in Fig. 2, are arranged vertically, and the framing which is of wrought iron is so arranged as to take the whole thrust of the engines in itself independently of the boiler to which is simply bolted. The cylinders are $7\frac{3}{4}$in. in diameter, and 10in. stroke. The crank shaft which is 3in. in diameter carries a pinion at each end sliding on feathers, which are about 8in. in diameter. There is also an

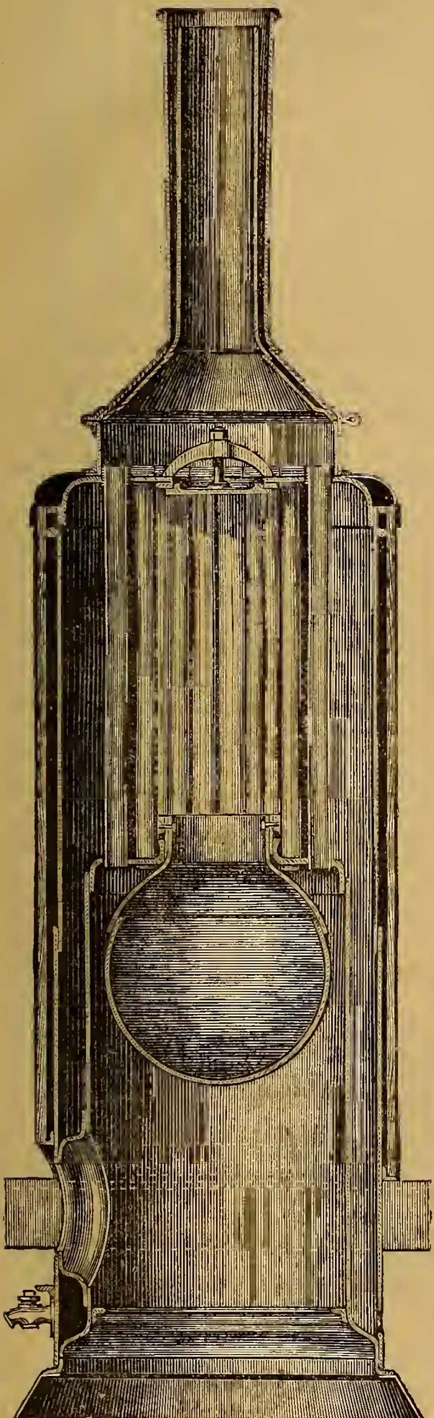


Fig. 1.

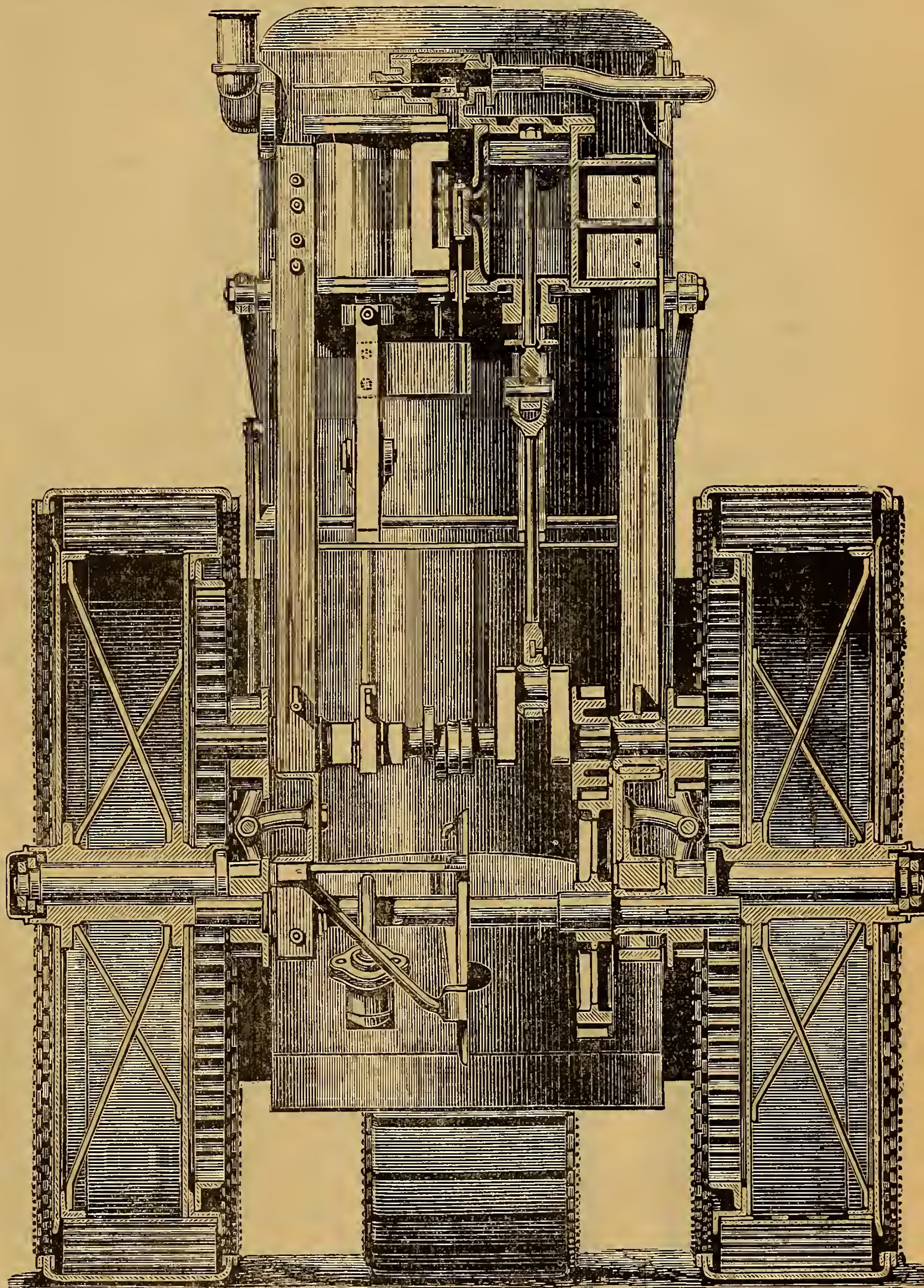


Fig. 2.

intermediate shaft for multiplying the power when required, the whole of the gearing being 1¾in. pitch. The driving wheels are 6ft. in diameter, and the leading wheel 4ft., the india-rubber tires being 5in. thick.

It remains only to mention that this locomotive was tried publicly at Lincoln, before being sent to the Smithfield Show, where it proved its great power and utility both in dragging heavy loads up a steep hill, and also in performing several astonishing evolutions over wet swampy land.

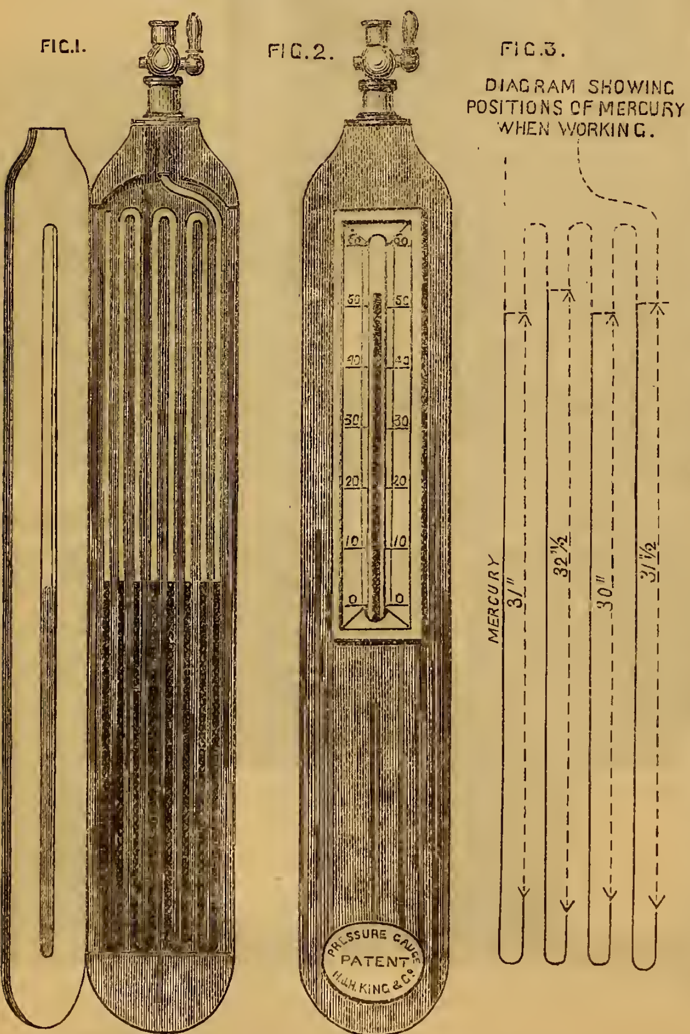
MERCURIAL STANDARD PRESSURE GAUGE.

By Messrs. H. J. H. King and Co,, Glasgow.

The want of a perfectly reliable pressure gauge has no doubt, been felt by most engineers, but with the exception of the old-fashioned mercurial gauge, it was until lately impossible to rely upon any one of the numerous different arrangements that have been constantly brought forward. It is only for old-fashioned low pressure engines the common mercurial gauge is available, and for this purpose it is undoubtedly still unsurpassed for accuracy ; but as most stationary and marine engines at present in use are worked at pressures varying from thirty to fifty or sixty pounds on the square inch, this form of gauge becomes impracticable, in consequence of the enormous length to which it would have to extend. In order to overcome this difficulty, Messrs. King and Co., have hit upon a plan of making this gauge come within reasonable limits without in any way interfering with its efficiency.

In the accompanying engraving, Fig. 1 shows the arrangement of the

FIG.1. FIG.2. FIG.3.



tube, Fig, 2 the appearance of the gauge and the diagram, Fig. 3 illustrates the action of the gauge. It will be seen that the gauge consists of a glass tube bent into a series of U's as shown in Fig. 1. The lower portion of each U is filled with mercury, and the upper portion with glycerine. On the application of pressure at one end of the tube, the mercury assumes a position similar to that shown in diagram (Fig. 3), being depressed in one of each pair of tubes and raised in the other ; and the pressure will be equal to the summation of the lengths of the four columns of mercury, minus the weight of a corresponding length of glycerine. The tap affixed to the gauge is so constructed that no water or any impurities from the boiler can enter the tube, so that there is no liability to freeze or clog up.

THE INTERNATIONAL EXHIBITION.

The following is a list of the dates fixed for the reception of objects intended for exhibition in the International Exhibition to be opened Monday, May 1. Objects sent or brought after the days appointed for their reception cannot be admitted. Machinery, February 1, 2, 3, and 4; scientific inventions, February 6 and 7; educational works and appliances, February 8 and 9; pottery and raw materials, February 10 and 11; woollen and worsted fabrics, and raw materials, February 13 and 14; sculpture not applied to works of utility, February 15 and 16; painting applied to works of utility, February 16; sculpture applied to works of utility, February 18 and 20; engraving, lithography, photography, &c., February 21; architectural designs, drawings, and models, February 22; tapestries, carpets, embroideries, &c., February 23; designs for all kinds of decorative manufactures, February 24; copies of pictures, mosaics, enamels, &c., February 25; and painting not applied to works of utility, February 27 and 28. In division II., manufactures, Classes 8, 9, and 10 (in which the various objects coming under the head of Class 8, pottery of all kinds, with new raw material, machinery, processes, &c.; Class 9, woollen and worsted fabrics, with raw material from new sources or prepared by new processes and new machinery for woollen and worsted manufactures; and Class 10, educational works and appliances, will be exhibited), a form containing the following questions to be filled up for the catalogue has been issued to intending exhibitors, and must be returned with the various objects :—Class No. to which the object belongs—1, name and use of object; 2,* materials of which the object is made; 3, date of manufacture; 4,* its price; 5,* names of persons employed in its production; 6,* any other information; 7, manufacturer's name; 8, his address; 9,* the date of the establishment of his business; 10*, the honours which he has attained. Her Majesty,s Commissioners are of opinion that the addition of the particulars marked thus * will be useful and interesting to the public, but it is optional with the exhibitor to supply them or not, as he may think fit. Every object must be accompanied by a descriptive label, stating the special reasons, such as excellence, novelty, cheapness, &c., why it is offered for exhibition. The Committee for the Selection of Pottery will consist of the following:—Lord Lichfield, Mr. C. M. Campbell, Mr. C. Drury Fortnum, Mr. M. D. Hollins, and Mr. Alfred Morrison.

OFFICIAL TRIAL TRIP OF THE "TENEDOS."

The *Tenedos*, 8 wooden unarmoured screw sloop, in charge of Commander A. P. Hastings, and Staff of the Steam Reserve, left Plymouth Sound on the 20th ult., to make the official trial of her speed in the offing. There were also on board Mr. J. Steil, R.N., inspecting officer from the department of the Controller of the Navy, Whitehall; Mr. Bardin, C.B., Chief Inspector of machinery afloat; Mr. Davison, patentee of the condensers; Mr. Kirk, representing Messrs. John Elder and Co., the builders of the engines; and Mr. H. J. Lonnon, of the Master Shipwright's Department at Her Majesty's Dockyard, Devonport. The ship was delayed in the offing until noon by fog, which obscured the marks; it then cleared, and the trial was proceeded with. The following was the result:—Ship's draught forward, 13ft. 4in.; aft, 16ft. 4in.; bar., 29·58; ther. on deck, 45 deg.; below, 70 deg.; wind, north; force, 1; sea, smooth; six runs on the mile at full boiler power gave a mean speed of 12·961 knots per hour; mean revolutions, 99·34 per minute; mean steam pressure, 50·5lb. Four runs at half boiler power realized a mean speed of 11·021 knots per hour, with mean revolutions 83·31 per minute, and mean steam pressure 54lb. Four circles were also made, the first at full power, with port helm, angle of rudder 18 deg., the half circle occupied 2min. 33sec., the whole circle 4min. 51sec., diameter of circle 547 yards. In the second, at full power, with starboard helm, angle of rudder 20 deg., the half circle took 2min. 16sec., the whole circle 4min. 18sec., diameter of circle 420 yards. In the third, at half boiler power, with port helm, angle of rudder 20 deg., the half circle occupied 2min. 42sec., he whole circle 5min. 20sec., diameter of circle, 547 yards. In the

fourth, at half boiler power, with starboard helm, angle of rudder $20\frac{1}{2}$ deg., the half circle took 2min. 44sec., the whole circle 5min. 14sec.; diameter of circle, 420 yards. The machinery worked exceedingly well throughout the trial, and to the entire satisfaction of the authorities present.

THE IMPERIAL OTTOMAN NAVY.

The Turkish Government have not been behindhand in availing themselves of modern instruments of warfare. They have already in stock 200 Gattling mitrailleuses, and will be in receipt of 200 more by the time that the London Conference has decided whether Turkey will want them or not.

Number of Ironclads belonging to the Imperial Ottoman Navy.

	Name of Ship and description.	No. of Guns.	Weight of Shot in lb.	Horse Power.
1.	*Azizieh*, frigate	15 1	150 300	900
2.	*Orkaniyeh*, frigate	15 1	150 300	900
3.	*Osmanieh*, frigate	15 1	150 300	900.
4.	*Mahmoudieh*, frigate	15 1	150 300	900
5.	*Arthar-Tevfik*, frigate	8	250	700
6.	*Fethi-Boulend*, corvette	4	300	500
7.	*Avni-Illah*, corvette	4	250	400
8.	*Muin-Zaffer*, corvette	4	250	400
9.	*Athar-Shefket*, corvette	1 4	250 120	400
10.	*Neyim-Shefket*, corvette	1 4	250 120	400
11	*Idjla-Lieh*, corvette	1 4	250 120	400
12.	*Lutf-Gelil*, corvette	2 1 1	150 40 32	200
13.	*Hufz-Rahman*, corvette	2 1 1	150 40 32	200
14.	*Fethi-Islam*, gunboat	2	9in. bore	150
15.	*Beksor-Selim*, gunboat	2	9in. bore	150
16.	*Semendirah*, gunboat	2	9in. bore	150
17.	*Ishkodrah*, gunboat	2	9in. bore	150
18.	*Bonkoritcha*, gunboat	2	9in. bore	150
19.	*Mukaddemme-Khies*, corvette, building.			

THE COPPER ORE TRADE.

The imports of foreign copper produce during the quarter ending December 31, at Swansea, have been 7,666 tons of ore, 6,876 tons of regulus, and 2,175 tons of copper. Of this there were 1,100 tons of Australian ore transhipped by coasters to Swansea; 58 tons of Cape, and 184 tons of Canadian ore. The exports from Swansea during the same period were 169 tons 14 cwt. 1qr. 22lb. of copper produce; and the ores sold at the Swansea ticketings during the three months were 883 tons of foreign, which realized £11,453 7s.; and 1,010 of British, which realized £7,075 4s. 6d.; making a total of 1,893 tons, amounting to £18,528 11s. 6d. The stocks of foreign copper produce remaining unsold at Swansea on the 31st of December last were 9,008 tons of copper ore, 9,917 tuns of regulus, 3,562 tons of copper, and 245 tons of barilla, representing about 10,180 tons of fine copper. The copper market during December has exhibited a gradual improvement in tone and prices of furnace material have remained steady, at 12s. 6d. to 12s. 9d. On the 20th of December the smelters advanced their official quotations £3 per ton; the same advices were received by cable from Chili, giving 3,800 tons of pure copper as chartered for in the first half of November, and on the 28th 1,600 tons pure. Messrs. Richardson and Co., in their monthly circular, commenting upon the present state of the copper ore trade, say:—"The year which is now closing will be remembered by all connected with copper mining and manufacture from the fact that the metal had touched (in October) the lowest point of value for a century and a half. It is some satisfaction to find the cause of this unprecedented depreciation, not in any inherent rottenness in the trade itself, but in the unhappy events which have formed the history of Europe for the last six months; and we may be allowed to hope that when the war which is devastating France and withdrawing from industry the working population as well as the capital of Europe shall have been brought to a termination, a natural revival will set in. The almost entire stoppage of manufacture and consumption in France will undoubtedly be followed by a large absorption of the metal to be supplied from this country. Our home trade has been on the whole in a healthy condition throughout the year, and we are warranted in believing that the long period of depression through which we have passed will be succeeded by better times."

SHIPPING.

During the year the employment for sailing vessels has been of a very unremunerative character. Steamers engaged in short voyage trades have been profitably employed, but in the East India and China trades the excessive competition *viâ* the Suez Canal has brought down both outward and homeward freights to an unprofitable point. The successful opening of the Suez Canal and the lessened consumption of fuel by the now general adoption of the "compound" engine, induced a popular and to a considerable extent fallacious opinion, that the carrying trade of the world would immediately be done solely by steamers, the consequence being that a very large construction of vessels of this description is now going on, while there is hardly a sailing ship building. That there will be a plethora of steam tonnage during 1871 we very much fear, and this will also, doubtless, materially counteract the benefit sailing shipowners would otherwise naturally have derived from non-production. The outbreak of the war, and the uncertainty at the time as to other nations being involved, produced some activity in freights, especially in the grain trade; subsequently the restricted commerce which ensued more than counterbalanced the virtual exclusion of the German shipping, and for three or four months there has been great dulness generally. There is now some animation. The German mercantile marine amounts to about 1,260,000 tons, the greater part of which is at present laid up. The Suez Canal has continued in good working order throughout the year, and since its opening, in November, 1869, the amount of steam tonnage which has left England for the East by this route exceeds 170,000 tons register.

AMERICAN RAILROAD ACCIDENT.

An express train was running on the Mississippi and Tennessee Railroad on the 3rd of January, when an axle broke, and a passenger car was thrown down an embankment, and, the stove in the car falling over, the car was in a blaze before the passengers could make their escape from it. Seven coloured persons were so burnt that it was impossible to identify the bodies. One man, on whom the stove fell, presented the appearance of having been burnt alive in it. About 30 other passengers were scorched and hurt, but escaped alive. The car was first thrown across the track, and a rail, torn from its place, was forced into the car, and penetrated it from end to end.

REVIEWS AND NOTICES OF NEW BOOKS.

Inorganic Chemistry. By W. A. Miller, D.C.L., L.L.D., &c., &c. London: Longmans, Green and Co.

Messrs. Longmans have undertaken to publish a series of "Text Books in Science," edited by T. M. Goodeve, M.A., and written either by him or by some well known authority upon the peculiar subject to be treated upon. The immense impetus lately given to the cause of education, has created a great want for such a series, the supply of which we are are glad to find has been undertaken by such an eminent firm as Messrs. Longmans.

The treatise on inorganic chemistry which forms one of this series, was just completed by Professor Miller, when he was seized with that sudden and fatal illness at Liverpool, while attending the meetings of the British Association. As, however, before his decease, he intrusted the revision of the work to the able hands of Mr. Tomlinson, the book has not suffered through that calamity.

Although the book professes to be only an elementary treatise, it appears to be exceedingly complete, and may be studied with advantage by matured students of chemical science, especially those who having learnt in the old school, desire to become familiar with modern chemical nomenclature.

A new Map of Metropolitan Railways, Tramways and Miscellaneous Improvements. Deposited at the Private Bill Office, Nov. 30th, 1870, for Session 1871. London: Edward Stanford, 6 and 7 Charing-cross.

The London tramway mania has assumed such large proportions as to call for a new map of the Metropolis, illustrating their various routes, and thereby enabling the public to take full advantage of this pleasant method of travelling. This task appears to have been very ably accomplished by Mr. Stanford, and we can confidently recommend a previous inspection of this map to all intending travellers through London.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Petroleum.—Last year's business in refined American oil was on a most enormous scale, the exports from the United States up to the 16th of December, 1870, reaching the total of 3,254,374 barrels, against 2,496,046 barrels for the whole of 1869, although the shipments of 1869 were in excess of any former year. It would thus appear that the supply is almost inexhaustible; and as the value of the year's shipments is about £8,000,000, it will be seen how important a part petroleum plays in the worlds commerce. It is deplorable that the Act of 1868 should, as it most undoubtedly does, seriously interfere with the growth of the trade in this country. The dealers of the United Kingdom are harrassed by laws that have no parallel either in America or the great consuming countries of the Continent. Meantime the English public continue to pay higher prices than the inhabitants of more distant countries, who are not forced to import a special article, while the really dangerous petroleum spirit, or benzoline, is still admitted into our ports in growing quantities.

At a meeting of the Philosophical Society lately held in the East Hall of the Upper Corporation Galleries, Dr. Bryce read an interesting paper "On the question as between Sir Roderick Muchison and Professor James Nicol in regard to the age of the rocks of the Central Highlands."

On board a screw, lying at the Weir, trial was lately made of a "fire-destroying" agent, patented by Messrs. Paton & Harris. A quantity of shavings and wood splinters in the hold of the vessel, was set on fire and covered over; carbonate of soda in solution, and muriatic acid, in about equal proportions, were then pumped in and generated a gas which extinguished the fire in a few minutes. The invention promises to be useful in the event of fire occurring in the hold of a vessel; but of course it will not act in any place where there is free circulation of air.

The capital engaged in nine Pennsylvanian steel manufacturing establishments is estimated at 4.500,000 dols. The annual production amounts to 18,400 tons.

The Westminster District Board of Works have agreed to a payment of £200 to Mr. Cooper for eighty tons of his patent salts for watering the roads in the district.

Petroleum has been discovered at Cape Breton, Nova Scotia, and the discovery has created quite a *furore*. A company which had been boring at Lake Ainslie "struck oil" on Dec. 9th, at a depth of 560ft., and the oil is still flowing. In consequence of this discovery several new companies have been started to prosecute the industry, and large tracts of land have been leased for the purpose. The petroleum is said to be of high quality.

A saving is about to be effected in ropemaking at the Chatham dockyard by turning to profitable account the refuse from the hemp. Some 5 per cent, of the hemp used in the ropery at Chatham dockyard became useless by its conversion into dust and refuse in the course of manufacture; and the consumption of hemp annually in Chatham yard, is 1100 to 1200 tons. This refuse has hitherto, as useless, been burnt; but it is understood that an offer has been made to, and accepted by, the authorities to purchase this refuse at £11 per ton, it having been found that it can be used in the manufacture of paper.

California is building street cars with compartments for freight and dogs.

It is proposed to erect a lock on the Thames between Kew and Richmond, where at present the mud accumulates so much as to impede navigation.

The post-office pillar boxes in New York are connected by a pneumatic tube that runs round the city to the general recieving house. As the letters are dropped into the box they are blown along the tube at a rate of sixty-five miles an hour.

The successful application of steam fire engines in this country has at length induced our Indian Government to take the matter in hand, Madras being selected for this experiment. The engine in question is one of Shand, Mason, and Co.'s, so well known in the Metropolitan Fire Brigade. It was tested on the 10th. ult. at the India stores Department, Belvidere-road, in the presence of Mr. Lamb and other officers of the department. The fire was lighted at quarter before three o'clock, and in eight minutes and a-half a steam pressure of 100 lb. on the square inch was obtained. The water was drawn from the river, from the depth of about 10ft., and was projected through various jets in succession, ranging from 1in. to 1¼in. The stores buildings facing the river are 75ft. in height, and with a flagstaff on the top, a height of 120ft. is obtained; the water from the jets was thrown about 20ft above this flagstaff. The engine is the small size, and was specified to deliver 250 gallons per minute, but in the trial for quantity in the measuring tank, 270 gallons were delivered in one minute.

Balloons in War.—A committee has been appointed, with Captain Beaument, R.E., M.P., as president, and Lieutenant Grove, R.E., and Mr. Abel, F.R.S., as members, to carry out experiments on the utilisation of balloons for reconnoitring purposes.

The traffic now being forwarded through the French Atlantic cable averages above 7,000 words daily, being at the rate of five words a minute for the whole 24 hours, a speed which suffices to clear off all the messages sent within the day. On some days nearly 10,000 words have been transmitted in the 24 hours, showing that the capacity of the cable is much more than sufficient to convey the present average traffic.

A trial of Barbour's patent adjustable nozzle which can easily be substituted for the one generally in use—lately took place in St Enoch Square, in presence of Councillor Brown, Chief-Constable M'Call, Mr. Bryson, Superintendent of the Fire Brigade, and others. The nozzle consists principally of a jet suitably formed to deliver a solid stream of water, as in the case of the ordinary nozzle; but when it is desirable to spread the water, a slight turn of the wrist causes a number of metal "fingers" to stretch across the valve, whereby the jet of water is distributed to any extent required. The trial was very satisfactory, and several of the gentlemen present were of opinion that the patent nozzle would be of great use in connection with cleansing operations.

TELEGRAPHIC ENGINEERING.

The directors of the Western Union Telegraph Company have decided to recommend no dividend for the half year ending December 31. This is the second half year in which the company has paid no dividend. It is stated that the company is willing to transfer its undertaking to the American Post Office.

The West India and Panama Telegraph Company (Limited) state that the submarine cable has been successfully laid between the islands of St. Thomas and Porto Rico. They add that the section between Porto Rico and Jamaica is being proceeded with.

The British Indian Extension Telegraph Company have received intelligence of the successful laying of their cable between Singapore and Madras. This completes the line of submarine telegraphic communication from England as far as Batavia.

SHIPBUILDING.

Iron shipbuilding has been carried on at Hull with very great activity during the year 1870. The two yards upon the banks of the Humber have been fully employed during the whole of the year, and each has on hand orders that will occupy it far into 1871. Messrs. C. and W. Earle have launched from their yard nine steamers, all of large tonnage, the least being 850 tons register, and the largest over 3,000 tons. The vessels built at this yard during the year represent a total of 12,696 tons and 1,800 horse-power. Messrs. Earle also have in their yard, in various stages of progress, seven screw steamers, representing a total of 13,600 tons and 1,500 horse-power. Messrs. Humphrys and Pearson have launched from their yard five steamers, each one being over 1,200 tons register, the total tonnage being 6,781 and the horse power 720. In this yard the total tonnage last year was 2,462 with 260 horse power. Messrs. Humphrys and Pearson have now on the stock seven large steamers, with a total of about 10,000 tons. Most of the vessels built at these yards have been for Hull owners, and they, with others built on the Clyde and the Tees, make an addition to the fine fleet of Hull steamers of about 32,000 tons. There have only been three Hull steamers lost during the year—viz., the *Plato*, which foundered with all hands in the Bay of Biscay; the *Juno*, which went ashore on the Scaw in December; and the *Hull*, wrecked near the *Juno*. The two latter vessels went on shore during a fog.

LAUNCHES.

A large steamer, built to the order of R. Little, Esq., of Greenock, for the Anchor Line, was lately launched from the building yard of Messrs Robert Duncan & Co., at Port Glasgow. The launch was a most successful one. On leaving the ways the vessel was named the *Assyria* by Miss Auderson, daughter of James Anderson, Esq., of Higholme, and was thereafter towed up to Finnieston Works, to receive her engines.

On the 10th. ult. there was launched from the shipyard of Messrs. J. & G. Thomson, of Govan, the screw steamer *Gothland*, for Messrs. James Currie & Co., of Leith. The *Gothland* is of 1400 tons and 200-horse-power compound engines supplied by the builders. She is intended, along with the *Iceland*, also buildng by Messrs. Thomson, for Messrs. Currie's continential trade.

On the 19th ult. Messrs. J. Wigham Richardson, and Co., launched a handsome screw-steamer of 1,450 tons hurthen, and 110 horse power, intended for the Black Sea and Danube trades. She was christened *pro tem.*, being for sale, and is now lying under the shears taking in her machinery.

On the 21st ult. Messrs. John Elder and Co. launched from their shipbuilding yard at Fairfield, Govan, an iron screw steamship of 2,789 tons b.m., and 600 horse-power nominal, for the Royal Mail Steam Packet Coy. of London. The vessel has been designed and constructed for that company's service between Great Britain and the West Indies, and is of the following dimensions:—Length between perpendiculars, 344ft.; breadth, 40ft.; depth, moulded, 35ft. Her accommodation for passengers is of the most superb description. Besides providing comfortable accommodation for 75 second-class and 50 third-class passengers, she is furnished with cabins and sleeping apartments in the highest style of elegance and comfort for 270 first-class passengers. This vessel is similar in construction to the *Elbe*, launched by the same firm fifteen months ago, and which has proved so successful. The firm have a sister ship to the *Tagus* now building to be named the *Moselle*. They are also transforming the *Tasmanian* to the same arrangements as the *Tagus*, with engines of similar dimensions: and it is expected that the *Tasmanian* will perform the same service as she did formerly on one half the consumption of fuel. As the ship left the ways she was gracefully christened the *Tagus*, by Miss Bevis, daughter of Captain Bevis, superintendent of the Royal Mail Steam Packet Coy.

A large new dredger, built and engined by Wm. Simons & Co., was launched on the 21st. ult. from their London Works, Renfrew. This vessel is the property of the Clyde Trust, and will be the most powerful dredger on the river Clyde. Its dimensions are—Length, 161 feet; breadth, 30 feet; depth, 10½ feet; and it is fitted with two condensing engines of 70 horse power; the bucket girder is nearly 100 feet long, and its massive proportions are such as to resist the various strains when working in 30 to 35 feet water, and it is fit for raising 5000 tons per day. A novelty in the working details of construction are various heavy steel castings, such being considered better suited for severe dredging operations and the difficulty of procuring good steel of the necessary irregular form and strength caused considerable difficulty and delay. Another novelty adopted under the directions of Mr. Deas, the Clyde engineer, is the double slide shoots for discharging, which are driven by steam, and expected to economise both time and labour. This is the eighth vessel Messrs. Simons have built for the dredging operations on the Clyde, and on it has been applied every improvement derived from their extensive experience. They have also in progress several other dredgers, one of which (for Dundee) will be launched in a few days. They are also constructing for a foreign Government one of their patent combined steam dredge hoppers, which will proceed to sea with its own spoil.

Messrs. Alex. Stephen and Sons launched on the 24th ult. from their new works at Linthouse, the iron three-decked steam ship *Glensannox*, 1,509 tons, and 100 A at Lloyd's. The engines are by Messrs. J. and J. Thomson, Finnieston Engine Works. The *Glensannox* is a sister ship to the *Glendarroch*, lately launched by the same parties for Messrs. Wm. Ross and Co., and is to be employed in the Eastern trade *via* Suez Canal. The ceremony of naming was performed by Mrs Wm. Ross of Crookstonhall.

Mr. J. G. Lawrie launched on the 23rd ult. at Whiteinch a steamer of 1,100 tons for the Leith and London passenger trade. The machinery is being made by Messrs. James and George Thomson, and is to be fitted in the most improved manner for efficiency and economy of fuel. The steamer, which will be one of the fastest afloat, was named *Marmion* on leaving the ways by Miss Macpherson.

TRIAL TRIPS.

The armoured iron-built frigate *Bellerophon*, 14 guns, 4,720 tons, 1,000-horse power, screw engines by Penn and Son, refitted for re-commission at Portsmouth, and fitted with new boilers, made her official trial of speed on the 10th ult., at the measured mile in Stokes bay with very satisfactory results. Staff-Commander Fawckner, of the Portsmouth Steam Reserve, commanded the frigate *pro tem.* The frigate drew 20ft. 5½in. of water forward, and 25ft. 6½in. aft. Six runs were made over the measured mile under full boiler power, and the mean speed of the frigate was found to be 13·904 knots per hour, the mean revolutions of the engines being 72·75 per minute. Two runs made over the mile under half-boiler gave the ship a mean speed of 11·780 knots per hour, the mean revolutions of the engines being 60·5 per minute.

On the 9th ult., a screw steamer, built by Messrs. Dobie and Co., of Govan, and engined by Messrs. William King & Co., of Glasgow, proceeded down the river on her trial trip. The vessel is 140 feet long, by 20.6 beam. by 10.9 depth of hold. The engines are on the compound principle, of 50 nominal horse-power, fitted with surface condensers, jacketed cylinders, and all the latest improvements. The speed was tested on the measured knot at Skelmorlie, with 300 tons deadweight on board, and the result of four runs, with and against the tide, gave a mean of 9·01 knots. Throughout the whole day the engines worked with great smoothness, and the results stated were considered most satisfactory.

The *Revenge*, 73, screw ship, 3,322 tons, 800-horse power, having received new boilers and completed her refit in Her Majesty's Dockyard at Keyham, left the harbour on

the 12th ult., and steamed to the Eddystone and back for the trial of her machinery. The ship was in charge of Capt. Charles Fellowes and staff of the Steam Reserve, and the machinery trial was superintended by Mr. Bardin, C.B., chief inspector of machinery afloat. The weather was very fine, the sea smooth, the wind N.E., force 1 to 3; the barometer, 30·20; thermometer, 45 degrees. A mean speed of 11·89 knots per hour was obtained, with mean revolutions per minute 51·5; mean pressure of steam, 17lb.; and mean vacuum, 25½ inches. The new boilers on board the *Revenge* are 100-horse power less than the old ones, and were originally made for the *Duke of Wellington* (flag-ship at Portsmouth). The trial was considered in all respects satisfactory.

RAILWAYS.

The amount earned by the South Italian Railway Company in the first forty-eight weeks of last year was £489,532, as compared with £435,579, in the corresponding period of 1869, showing the substantial increase of £53,953. Next year the receipts of the company may be expected to present a considerably further increase, the Mont Cenis tunnel being now nearly ready for the passage of trains.

The *Architect* says it is understood that the South Eastern, North Western, and Midland Railway Companies, will guarantee a certain amount of traffic to the projected railway from Charing Cross to Euston-square, and St. Pancras, and the Metropolitan Board of Works will give £200,000 towards the formation of the new street which is part of the scheme.

A peculiar feature in each of thirty-three new locomotives built at the Rhode Island works for the Great Western Railway of Canada, is the placing of the bell in front of the engine, with gearing to the driving wheel, so that every revolution rings it.

The Iron Company of St. Louis, Mo., have contracted to build five hundred freight cars for the Missouri, Kansas, and Texas Railroad.

It is reported that the Central Pacific Railroad Company have purchased the Central Utah Railroad, and intend to push it through to connect with the Kansas Pacific Railroad.

The Board of Trade annual returns for the past year show that 15145¾ miles of rail way exist in the United Kingdom, 10,773¾ of which are in England, 2,397 in Scotland and 1,975 in Ireland.

The returns recently issued show that in the year 1869 trains travelled 157,532,255 miles on the railroads of the United Kingdom, so that, upon an average, in every second of time five miles of railway were covered by a train. The railway companies received, upon an average. 65d. every time a mile was covered by a train. Very nearly half the money was absorbed by the working expenditure; 51 per cent. was profit. The year's receipts from all sources of traffic were equal to 27s. 11d. from every person—man, woman, and child—in the United Kingdom. The fares paid by ordinary passengers averaged 12½d., and the journeys taken by them were nearly ten times the estimated number of the population; the season, or periodical ticket-holders, 96,214 in number, paid upon an average £6 11s. 2d. for the ticket, but the number of journeys made for the money is not shown. In 1869, upon an average, every three weeks one railroad passenger was killed and 60 passengers were more or less injured (nearly three a day) from causes beyond their own control.

ACCIDENTS.

On the 17th ult. an explosion occurred on the steamship *Canton*, a new iron vessel recently launched on the Tyne, which had come round to Sunderland to be fitted with engines by the North-Eastern Marine Engine Company. Mr. Peter Dale Nichol, the managing director of the company, Mr. Allan, the manager, and several fitters and joiners were in the engine-room, the pressure indicating 40lb. to the inch, when a copper pipe of the stuffing-box connecting the steam from the boilers was blown out, and the steam and hot water from the boilers rushed out over Mr. Nichol, who was watching the operations, and received the full force of the scalding steam. Mr. Nichol and four others, who were more or less severely injured, were removed to the Infirmary, where Mr. Nichol expired the following morning. The other sufferers are doing well.

A disastrous accident recently occurred on the Madras Railway through the failure of a bridge over the Cheyair river. It is stated that the company proposes to reconstruct the bridge on a different plan to that adopted in the erection of the structure which gave way. The abutments at each end of the bridge will be built of granite, instead of brick and chunam, and the centre will be constructed with screw piles over which the girders will be placed.

DOCKS, HARBOURS, BRIDGES.

The graving dock at Port Chalmers has been carried on admirably by the contractors Messrs. Conner and M'Kay, and is rapidly progressing. On one side the last course of the stonework is laid, and on the other only one course is needed to raise the wall to the required height. The vast area of the dock can now be realised by visitors, as the floor throughout the whole length is partially laid. The pump shaft is formed, and two beautifully cast centrifugal pumps, each designed to throw out 10,000 gallons a minute, have arrived. This dock will be a great boon to the large class of iron ships now trading from the Clyde and other British ports.

MINES, METALLURGY, ETC.

Extensive discoveries of iron ore are being made in the Lake Superior region.

A ridge of black marble, ninety feet high and three-fourths of a mile long, has recently been discovered in Girardeau Co., Mo., U. S.

APPLIED CHEMISTRY.

When glue, in thick solution is mixed with tungstate of soda, and hydrochloric acid is added, there is thrown down a compound of tungstic acid and glue, which at from 30 deg. to 40 deg. Cent., is so elastic as to admit of being drawn out into very thin sheets. On cooling the mass becomes solid and brittle, but on being heated it becomes again soft and plastic. This material has been successfully employed, instead of albumen in calico printing, in order to fix the aniline colours upon cotton.

A plastic material of great resistance, suitable for a variety of uses, is prepared by M. Rost as follows:—He mixes litharge and glycerine so that they may form a creamy liquid. The mixture becomes, in a short time, a hard, homogeneous mass, which readily adheres to metal, resists the action of water and steam, and a temperature of 275 deg. Cent. In many instances this paste is preferable to red lead cement; and this glycerine litharge paste may be even used when in a very fluid state, for galvano-plastic copying, since this material preserves even fine engraved lines.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	73	0	0	,,	,,	,,
Tough cake and tile do.	71	0	0	,,	,,	,,
Sheathing and sheets do.	73	0	0	76	0	0
Bolts do.	74	0	0	,,	,,	,,
Bottoms do.	74	0	0	76	0	0
Old (exchange) do.	62	0	0	,,	,,	,,
Burra Burra do.	73	0	0	,,	,,	,,
Wire, per lb.	0	0	10	,,	,,	,,
Tubes do.	0	0	10½	0	0	10¾
BRASS.						
Sheets, per lb.	0	0	7½	0	0	7¾
Wire do.	0	0	7	0	0	7¼
Tubes do.	0	0	9½	0	0	10½
Yellow metal sheath do.	0	0	6¾	0	0	7
Sheets do.	0	0	6⅜	0	0	6½
SPELTER.						
Foreign on the spot, per ton.	17	17	6	18	0	0
Do. to arrive.	,,	,,	,,	,,	,,	,,
ZINC.						
In sheets, per ton	22	10	0	23	0	0
TIN.						
English blocks, per ton.	137	0	0	,,	,,	,,
Do. bars (in barrels) do.	138	0	0	,,	,,	,,
Do. refined do.	141	0	0	,,	,,	,,
Banca do.	135	0	0	,,	,,	,,
Straits do.	133	0	0	135	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	6	1	8	6
IX. do. 1st quality do.	1	12	6	1	14	6
IC. do. 2nd quality do.	1	5	6	1	6	6
IX. do. 2nd quality do.	1	11	6	1	12	6
IC. Coke do.	1	3	0	1	4	0
IX. do. do.	1	9	0	1	10	0
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	2	6	7	10	0
Do. to arrive do.	7	0	0	,,	,,	,,
Nail rods do.	7	5	0	7	15	0
Do. Stafford in London do.	7	15	0	8	0	0
Bars do. do.	8	2	6	9	2	6
Hoops do. do.	8	15	0	9	5	0
Bars do. at works do.	7	15	0	8	0	0
Hoops do. do.	8	2	6	8	5	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	6
Bars, common, do.	6	5	0	,,	,,	,,
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	0	0	6	5	0
Do. Swedish in London do.	10	0	0	10	10	6
To arrive do.	10	0	0	11	2	6
Pig No. 1 in Clyde do.	2	12	0	3	0	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. No. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	10	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	,,	,,	,,
English spring do.	17	0	0	,,	,,	,,
Quicksilver, per bottle	12	0	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	0	0	,,	,,	,,
Ditto L.B. do.	18	2	6	,,	,,	,,
Do. W.B. do.	19	15	0	,,	,,	,,
Do. sheet, do.	18	10	0	,,	,,	,,
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	21	0	0	,,	,,	,,
Spanish do.	17	10	0	17	15	0

* At the works 1s. to 1s. 6d. per box less.

LIST of APPLICATIONS for LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated December 14th, 1870.

3277 G. Bilbrough—Wardrobe latches
3278 J. Marshall—Tubes
3279 C. K. K. Bishop—Organs

Dated December 15th, 1870.

3280 T. T. Macneill—Barometers
3281 T. Day—Iron fencing
3282 D. McCorkindale—Furnaces
3283 A. C. Brice and W. Scantlebury — Knife or cutter
3284 H. Henchman—Generating steam
3285 B. W. Rogers—Screwing bolts
3286 W. Allan—Surface condensers
3287 T. Wilkinson—Ploughing
3288 J. Ascough—Candles
3289 J. Worrall—Singeing apparatus
3290 W. R. Lake—Springs

Dated December 16th, 1870.

3291 S. B. Birtill—Felted cloth
3292 J. Donald—Furnaces
3293 M. Mirfield and J. Scott—Combing wool, &c.
3294 W. H. Chase—Securing clothes upon a rope
3295 J. F. M. Pollock—Breaking cement
3296 J. Gamgee—Refrigerating machines

Dated December 17th, 1870.

3297 R. Baird—Punching apparatus
3298 W. Wilson—Weaving reps
3299 J. Hall—Utilising waste leather
3300 J. M. Hyde—Armour plated ships
3301 E. Keirby—Fog signals
3302 G. W. Rendel—Breech-loading ordnance
3303 H. Jones and W. W. De la Rue—Whist markers
3304 S. Smith—Cocks and valves
3305 S. C. Lister—Looms
3306 J. L. Hancock—Removing the skin from potatoes, &c.

Dated December 19th, 1870.

3307 G. E. Marchisio, H. B. Price, and J. E. Hodgkin—Extracting oil from olives
3308 D. G. Fitz Gerald—Voltaic batteries
3309 A. C. Moffatt—Door springs
3310 N. M. Henderson—Cooling paraffin solutions, &c.
3311 F. Hawley — Coupling railway carriages, &c.
3312 J. D. Lee and J. Crabtree—Looms
3313 B. P. Harris—Boats
3314 J. Rogers—Insulating wires
3315 R. Russell—Filters, &c.
3316 E. Foulger—Permanent ways
3317 W. J. Hopkins—Cultivation of land
3318 A. M. Silber and F. White—Lamps
3319 A. Sandeman—Folding, &c,

Dated December 20th, 1870.

3320 W. W. Kenuedy—Sewing machines
3321 L. Mariotti—Preserving meat
3322 J. Hargrave—Railway signals
3323 J. Reid—Liquid meter
3324 R. Tooth—Condensing juices
3325 A. M. Silber—Apparatus for lighting
3326 F. W. Haddan—Ships of war, &c.
3327 J. Hunter—Blast furnaces
3328 J. G. Willans—Furnaces

Dated December 21st, 1870.

3329 F. J. Walthew—Umbrellas, &c,
3330 W. P. Taylor—Curing smokey chimneys
3331 P. Taglis—Screwdrivers
3332 W. Williams—Shearing metals
3333 W. Firth—Dressing cannel coal
3334 P. Charles—Boxes for reels
3335 R. Boyd—Steam boilers
3336 J. C. Black—Slide valves
3337 A. Howatson—Furnaces
3338 S. Oddy—Self-acting mules
3339 T. Hopes—Lubricating composition
3340 J. Cook—Cutting lace
3341 S. J. Best—Apparatus for heating
3342 A. Sedley—Traction engines
3343 R. M. Lowne—Spirometers
3344 J. T. Griffin—Preventing nuts working loose in reaping machines
3345 W. Cook—Weather strip
3346 H. Y. D. Scott—Cement
3347 H. Bonnett—Waterclosets

Dated December 22nd, 1870

3348 O. Brooke and A. W. Read—Non-inflammable brattice cloths
3349 W. Spence—Bedsteads
3350 F. Jackson—Slide valves
3351 C. A. Calvert—Drawing off liquids
3352 A. F. Stoddard and C. B. Renshaw—Power looms
3353 J. L. Courtice and F. Webb—American organs
3354 W. T. Watts and D. J. Fleetwood—Hollow vessels
3355 J. Marshall and W. B. Harding—Slide valves
3356 J. Morrison—Locks, &c.

Dated December 23rd, 1870.

3357 J., W., J., and S. Willoughby—Stamping and breaking ores
3358 H. B. Young—Screw propellers
3359 R. Watts and J. S. Manton—Buttons
3360 A. Stewart, J. Stewart, and J. Wotherspon—Welded iron tubes
3361 J. Jackman—Attaching picks to handles
3362 J. and G. Anderton—Looms
3363 G. Clark—Percussion caps

Dated December 24th, 1870.

3364 C. Rawson, P. Ovenden, and W. McCree—Heating, &c.
3365 A. Bell—Economising fuel
3366 J. H. Johnson—Engraved plates
3367 J. Gamgee and W. H. Maitland—Medicating cotton
3368 W. Holdcroft — Utilisation of waste materials, &c.
3369 J. L. Davies—Preparing and printing musical notation
3370 J. Lawson — Raising the turrets of turret ships
3371 N. Clayton and J. Shuttleworth—Travelling wheels
3372 A. C. Bell—New cloak
3373 J. Loader—Cartridges
3374 L. and C. Petre—Match boxes
3375 G. Haseltine—Treadle mechanism
3376 W. R. Lake—Firearms, &c.

Dated December 27th, 1870.

3377 M. H. Kernaul—Sewing machines
3378 G. Haseltine—Preserving fruit
3379 H. Hughes—Securing corners of millinery boxes
3380 G. Bell—Candlesticks

Dated December 28th, 1870.

3381 J. T. King—Wood screws
3382 W. W. Pilkington—Opening out sheet glass cylinders
3383 D. Auld—Furnace doors
3384 H. Simpson—Cheese presses
3385 A. H. Thurgar and C. H. Capon—Manufacture of paper
3386 W. Robertson—New system of railway

Dated December, 29th, 1870.

3387 J. Wolstenholme—Pumping engines
3388 G. T. Bousfield—Viaducts
3389 S. C. Lister—Looms
3390 W. R. Lake—Steam generators
3391 W. R. Lake—Metal tubes
3392 S. A. Walsh—Paper stock, &c.

Dated December 30th, 1870.

3393 L. C. Lumley—Brushes
3394 G. Glover—Invalid bedstead
3395 G. P. Renshaw—Hydraulic breaks
3396 E. D. Nagel—Proceeding to cover steel with a blank sheet of nickel
3397 A. Field—Candles
3398 P. Brannon—Concrete works
3399 C. Rawson, P. Ovenden, W. McCree, and H. Hill—Deodorising sewage
3400 D. Yardley—Spades, &c.

Dated December 31st, 1870.

3401 J. Walsh—Preparation of cotton
3402 E. P. H. Vaughan—Preventing incrustation in boilers
3403 J. W. Ayres—Fastening for doors
3404 W. E. Newton—Felted fabrics
3405 R. A. Green—Earrings

Dated January 2nd, 1871.

1 J. B. Fell—Narrow gauge railways
2 R. Campbell and C. J. Appleby—Treating beet roots
3 E. J. C. Welch—Electric indicators
4 J. Bortcrill and R. W. Morrell—Crape cloth
5 A. M. Clark—Carpet beater
6 A. V. Newton—Sewing machines
7 W. R. Lake—Harvesting machines

Dated January 3rd, 1871.

8 W. A. Roadknight—Hats
9 T. Blanchett—Indicating apparatus for railway carriages
10 C. A. McEvoy—Effecting the explosion of torpedoes
11 J. H. Johnson—Lamps, &c.
12 G. A. Fernley—Steam boilers
13 A. Helwig—Feed mechanism for sewing machines

Dated January 4th, 1871.

14 J. H. Kenyon, J. Kenyon, and E. Entwistle—Railway signals
15 J. G. Cameron—Furnaces
16 J., W., J., and S. Willoughby—Stamping ores
17 J. Jeavons—Ascertaining the elongation of metals, &c.
18 W. H. Richardson—Treatment of ligneous materials
19 J. B. Payne—Manufacture of twines and cords

Dated January 5th, 1871.

20 H. W. Brand—Improvements in the preservation of milk
21 G. Haseltine—Tuck markers for sewing machines
22 R. Irvine—Phosphates to be used as fertilising agents
23 H. Larkin and W. White—Manufacture of sodium
24 C. Anderson — Transporting canal or other boats
25 A. V. Newton—Means of transmitting motive power
26 T. Higham — Improvements applicable to harmoniums

Dated January 6th, 1870.

27 J. Marsh—Signalling on railways
28 C. W. Chapman — Straightening and rolling iron
29 W. B. Mack—Steam boilers
30 W. L. Mitchell—Looms
31 E. Hodson and R. Hill—Improvements in railway signals, &c.
32 E. T. Hughes—Repeating firearms
33 E. T. Hughes—Plumbago presses
34 J. Gaukroger and J. Handley—Furnaces for consuming smoke
35 J. L. Bolding, J. T. Bolding, and J. Titsink—Waterclosets

Dated January 7th, 1871.

36 F. Norton and J. S. Davies — Steam boilers
37 J. Vogan — Preventing explosions in boilers
38 R. J. Little—Effecting communication
39 J. Lewthwaite — Dating or marking railway and other tickets
40 J. Blomerley—Boring railway sleepers
41 E. Hall—Means of expanding or contracting
42 H. Paterson—Affixing labels to bobbins
43 J. Russell—Improved safe-guard

Dated January 9th, 1870.

44 J. Quin and R. Eastham—Railway signals
45 W. MacKean—Steam boilers, &c.
46 W. H. Furlonge and J. D. Churchill—Manufacture of alkalies
47 A. Oldroyd—Tobacco pouches
48 J. Nasmith—Preparing for combing, &c.
49 C. E. Green and J. Grecu—Breech-loading fire-arms

Dated January 10th, 1871.

50 J. O. Ronchetti — Self-acting railway signalling apparatus
51 J. O. Ronchetti—Railway signals
52 G. H. Ellis and G. Gilbert—Adjustable plates for the shoes of horses, &c.
53 T. G. Messenger—Coupling of pipes
54 T. Hydes, J. Bennett and J. E. Bennett—Cooling liquids and condensing vapours
55 A. Blackwell and A. Bradshaw—Spring knife handles
56 M. G. Cole—Watches and timekeepers
57 J. Belicard and W. Ditchfield—Loom for weaving
58 T. Wrigley—Sleepers or bearers applicable to railways
59 J. Brock—Manufacture of letters, &c.
60 P. Adie—Lamps
61 E. Stanford and A. P. Price—Apparatus for registering, &c.
62 A. Duncan — Hoisting and lowering ships' yards
63 W. Randell—Preventing explosions
64 W. Bouch—Means of retarding locomotives
65 R. J. Nodder—Breech-loading fire-arms

Dated January 11th, 1871.

66 A. Lismann—Working metals
67 J. Norman—Manufacture of tubes
68 T. E. Harley—Signalling
69 G. Haseltine—Casting iron and steel
70 W. R. Lake—Machines for moulding
71 J. H. Nutt and G. E. Selby—Wrappers
72 W. H. Lascelles—Horticultural structures

Dated January 12th, 1871.

73 M. Hale—Carriage axles
74 J. A. Wade and J. Cherry—Construction of walls
75 H. M. Nicholls—Printing machines
76 R. G. Smith—Manufacture of paper
77 T. Rowatt—Horse-shoes
78 J. T. N. Buruand—Bar for winding up watches
79 H. Kenyon and I. Swindells—Production of sulphureous acids, &c.
80 H. B. Young—Window-blind mountings
81 F. W. Dahne and R. Hughes—Treating the bran saturated with palm oil
82 T. Huckvale—Saddles
83 L. H. Hanbury—Hair-curling
84 F. Aramburu—Cartridge pouches
85 J. F. Allen—Generating steam
86 G. Haseltine — Implement for tilling land, &c.
87 A. W. Pocock—Mortice locks, &c.

Dated January 13th, 1871.

88 R. Mills—Ship and other pumps
89 J. Scaife and T. C. Younger—Apparatus for washing, &c.
90 S. B. Darwin—Manufacture of gas
91 S. Smith—Cleaning chimneys
92 J. E. Hodgkin and E. Brasier—Cleaning flax, &c.
93 H. Pringle—Shoes for horses, &c.
94 W. Z. Cooke — Furniture and camp equipage
95 A. C. Sterry—Manufacture of candles
96 F. P. Preston, J. T. Prestige, E. J. Preston and W. A. Prestige—Discharging ashes

Dated January 14th, 1871.

97 J. Snowdon—Tools, &c.
98 C. Crossman and J. H. Ferguson—Iron shoes
99 H. Swan—Wheels, &c.
100 W. S. Wetmore — Protecting troops under fire
101 W. Avery—Receptacles for needles
102 W. Parnell—Window blinds
103 W. J. Menzies—Transmitting written or printed communications
104 L. Stewart—Wheels for carriages, &c.
105 E. Sonstadt — Manufacture of the acetates, &c.
106 J. A. Rhodes—Metals
107 W. Archer—Two wheel carriages
108 M. E. Baylis—Improvements in needle cases or wrappers
109 J. Harrington — Producing imitation morocco

Dated January 16th, 1871.

110 J. Crowther — Condenser carding engines
111 J. J. Hays—Apparatus for drying the bog-earth
112 R. Yeates—Provision tins or metallic cases
113 J. F. Allan—Illuminating gas
114 J. Barker and R. Bean—Furnace bars
115 J. A. Carteron and E. Rimmel—Substances impervious to moisture
116 J. F. Clarke—Melting snow

SUGAR MACHINERY,

BY

MESSRS WALKER, HENDERSON & Co

GLASGOW.

Fig. 3.

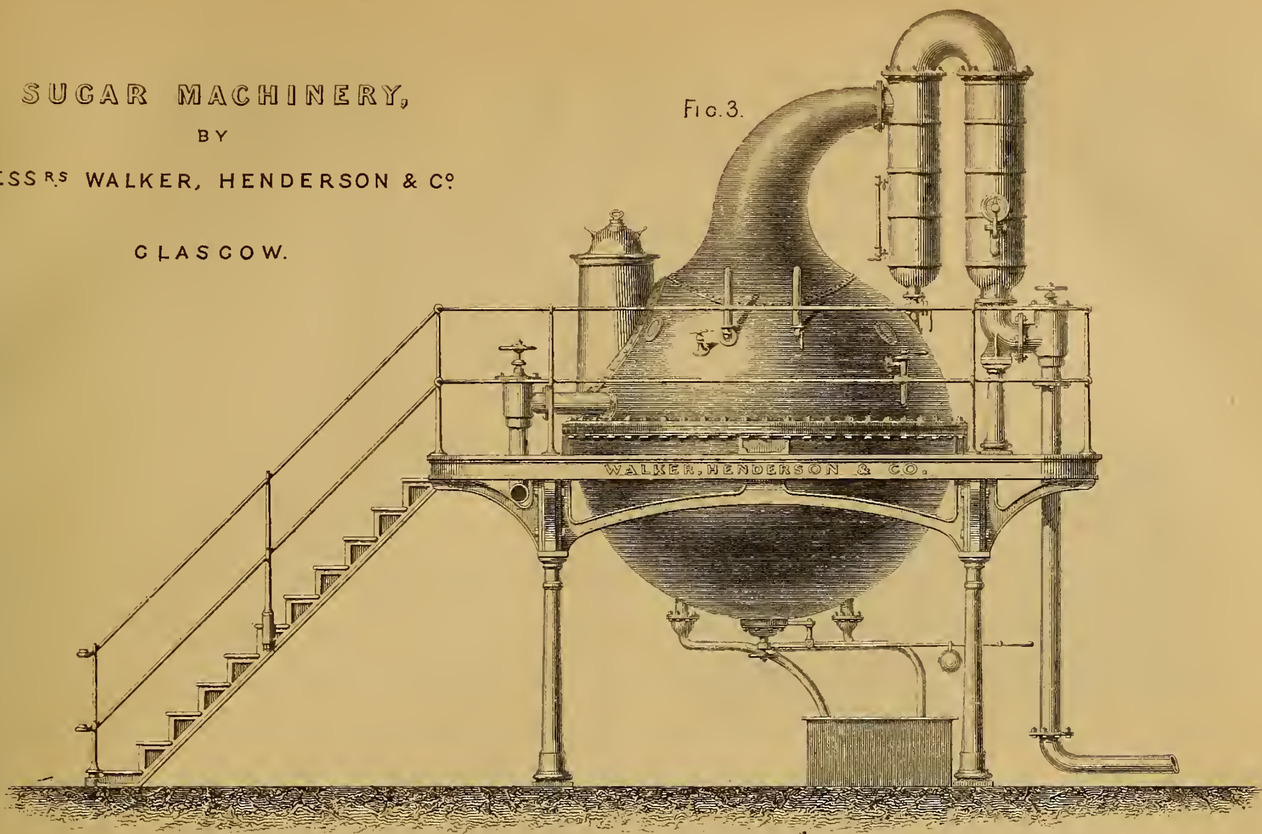


Fig. 5.

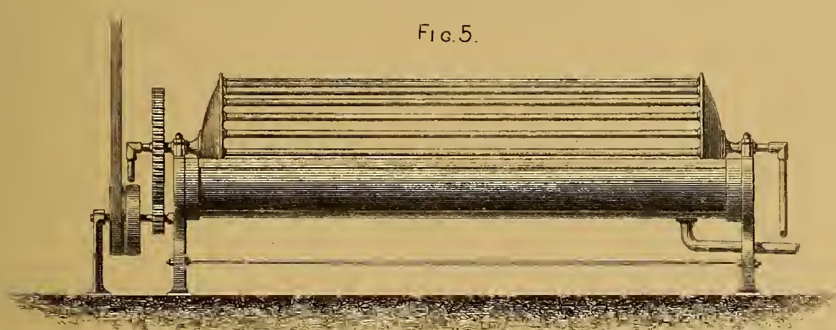


Fig. 6.

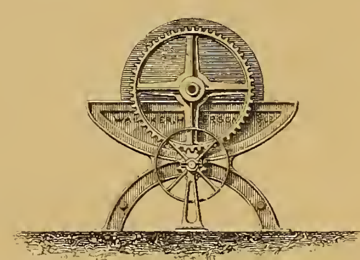


Fig. 7.

Fig. 4.

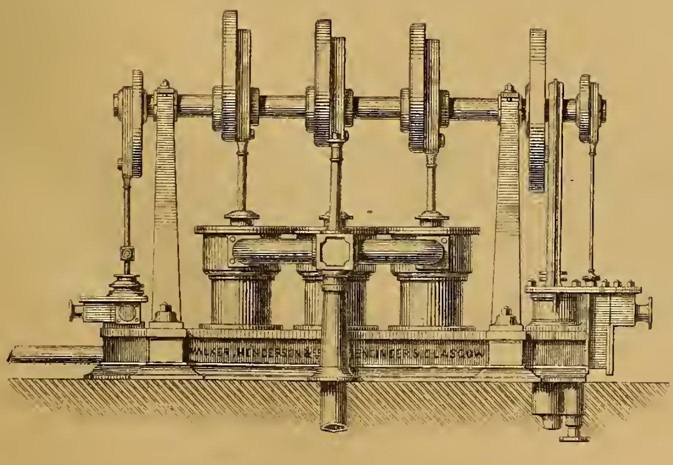


Fig. 8.

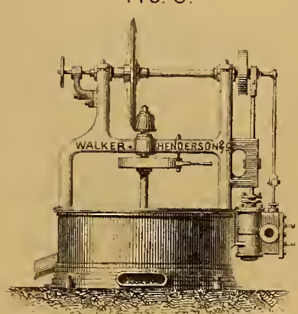
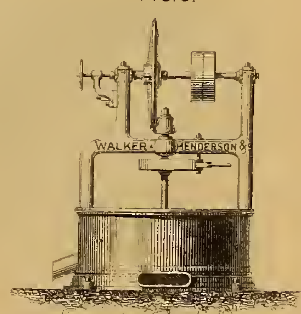


Fig. 9.



THE ARTIZAN.

No. 3.—Vol. V.—Fourth Series.—Vol. XXIX. From the Commencement.

1st MARCH, 1871.

SUGAR MACHINERY.

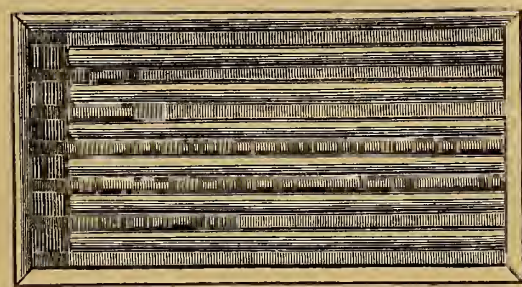
By Messrs. Walker, Henderson & Co., Glasgow.

(*Continued from page* 27.)

(*Illustrated by Plate* 371.)

In The Artizan of last month was given a description of the most common method of evaporating the water from the clarified cane-juice, wherein it was pointed out that althongh that method had the sanction of age it was very imperfect. Although the imperfections of this system might be shown to be very numerous, only the two greatest were insisted upon, viz., the enormous waste of fnel and the injury done to the sngar by excessive heat; as these two were amply sufficient, without taking into consideration the waste of labour in skimming, the incessant destruction of those pans nearest the fire and consequent stoppage of the entire manufacture, the choking of the flnes, and other minor drawbacks, to make it apparent that some change was absolntely necessary.

Leaving the former of these two objections—the waste of fuel—for the present, we will endeavour to show what has been done to evaporate the water at a temperature below that at which the sugar becomes materially discoloured. This temperature has been found to be at about 224° Fah., or when the liquor has attained the density of 32° Beaumé, the liquor then containing 40 per cent. of water and 60 per cent. of sugar. In practice, however, it is better to keep within this limit, and to confine the extreme temperatnre to about 220° Fah. when the density of the liquor is equal to about 27° Beanmé, or when the liquor consists of one half sugar and one half water. For the purpose of evaporating the cane-juice down to this strength several methods are employed. In some cases the use of the old range of coppers, as illnstrated in The Artizan of last month (page 26), may be continued, with the exception of the teaches, which are removed, and the fire placed under the first copper. In order to economise fuel, we remember having seen an arrangement adopted in Jamaica which gave very good results, which consisted in removing the two largest coppers and substituting a rectangular pan having a row of tnbes near the bottom, as illustrated in the accompanying engraving. By this means the evaporation was greatly



increased, the only objection to its nse being that it was somewhat difficult to clean, or, rather, the difficulty lay in ascertaining whether it had been properly cleaned. It has already been observed that cleanliness is of the utmost importance in these processes, and consequently the adoption of tubes, or, in fact, any unevenness in the pans cannot be recommended. A very simple arrangement for evaporating the juice is illustrated by Figs. 1 and 2, and is generally termed a "battery." It consists of a long and somewhat shallow vessel, usually abont thirty-five to forty feet long and four feet wide, the depth varying from about twenty inches at the end nearest the fire to about twenty-six inches at the other end. It is set in brickwork, the furnace being placed underneath the shallow end, a series of check bridges, as shown in Fig 1, being built in the flue, to obtain as mnch heat as possible. The brickwork is carried np a considerable distance above the top of the pan, and bevelled outwards, as shown in Fig. 2, the slope being covered with chunam, or waterproof cement. The battery is divided into four or five compartments by transverse partitions, having sluice valves at the bottom; these valves being worked by a hand lever, as shown in Fig. 2. When at work the liqnor in the battery boils up nearly to the top of the sloping sides, and the scum is thus easily swept along to the coolest end of the battery, and then skimmed off. By this means the labour of skimming off the impurities is not only very much reduced, but it is also

FIG. 1.

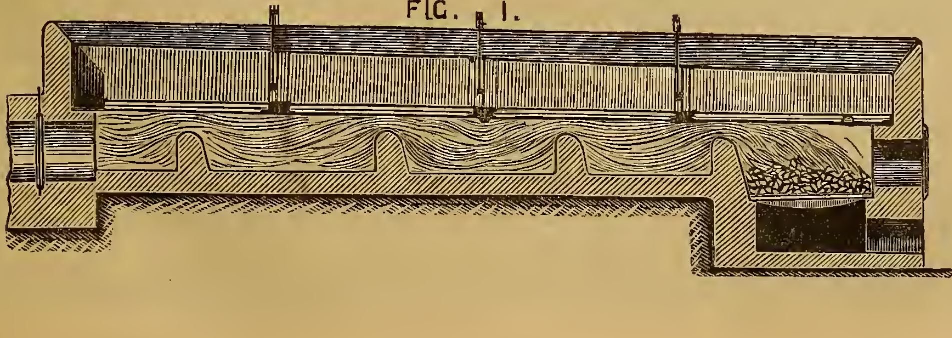
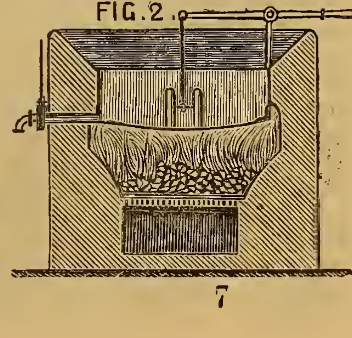


FIG. 2.



performed much more perfectly, and with less waste, as it is well known to all practical boilers that it is almost impossible to skim the liquor properly when boiling fiercely; besides which, the pure liquor necessarily taken up with the scum will not run through the perforations in the skimming ladle so readily when partially concentrated. By means of the sluice-valves the cane-juice can be admitted at pleasure from one compartment of the battery to the next, thus saving the labour usually required for incessant ladling from one pan into another. When the cane-juice in the compartment over the furnace attains a density of about 27° Beaumé it is drawn off by means of the cock shown in Fig. 2 into an evaporating pan, hereafter to be described, until but a few inches in depth remain at the bottom, when the cock is shut, and the sluice-valve communicating with the next compartment is opened to admit a fresh charge of juice. By leaving a few inches of liquor at the bottom all danger of burning and discolourisation is avoided, without it being necessary to stop the fire. When there is no more cane-juice in the clarifiers, and it is desired to "work off" or empty the battery, considerable skill, or rather, activity, is required to prevent burning. The juice is allowed to evaporate until the battery is about half full, when the contents of the compartment furthest from the fire are ladled over as quickly as possible into the adjoining space, the fire meanwhile being damped. Immediately this operation is completed the end compartment is filled with water, and the fire again urged until the same process is necessary with the next compartment, and so on until the whole of the juice is contained in the division over the fire. As soon as this attains a moderate degree of concentration (say about 24° or 25° Beaumé) the fire is drawn, and the whole of the juice run out into the evaporating pans.

In order to effect the evaporation of the surplus water at a temperature not exceeding that at which sugar becomes discoloured, or as has been already stated 224° Fah., various schemes have been devised. One of the first, and perhaps the most important was the vacuum pan, (shown in Plate 371, Fig. 3), invented by Howard about the year 1812, but as this pan is not only very expensive, but also requires skilled labour to manage it, we will first endeavour to describe some of the more simple methods that have been proposed. Although an enormous number of plans have been invented for effecting this object, they nearly all resolve themselves into the same principle, viz., that of exposing thin films of the heated liquor to the action of the air. In several plans the liquor is caused to traverse in very shallow streams, a tortuous course over steam heated plates of sufficient extent that the necessary quantity of water will be evaporated by the time it arrives at the end of its journey. It is obvious that these plans involved an enormous heating surface, and consequent large outlay in money, combined with an equally large amount of labour in keeping the surface clean. Besides, if at any time the heat of these surfaces varied, the liquor would be either under, or over boiled accordingly; consequently, these arrangements are thoroughly impracticable, and may be dismissed from further consideration. The first really practicable scheme with which we are acquainted, was invented about the year 1829, by Mr. Aitchison, of Glasgow. This plan consisted in the employment of a steam jacketted pan for the reception of the liquor, in which a cylinder closed at both ends was placed horizontally, and hung in bearings fixed at each end of the pan. The spindles carrying the cylinder were hollow, so as to admit of steam being passed into it. By means of a wheel and pinion, and a winch handle, the cylinder was caused to revolve slowly, and being fixed in such a position, that the lower surface dipped into the liquor contained in the steam jacketted pan, it continually carried round a thin film of this liquor, the water in which was rapidly evaporated. The objection to this arrangement was, that the cylinder or drum could not be placed low down in the steam pan without occupying too large a portion of its contents, while if it were placed sufficiently high to meet that objection, as the concentration proceeded, and the contents of the pan were diminished, it would not touch the liquor, and consequently became useless. There is, however, but little doubt, that this invention was an important step in the right direction, as all the most successful schemes since the date of that invention, bear a strong family likeness to it.

It does not appear that Mr. Aitchison's invention met with any favour at the hands of the planters, or, indeed, that they made the slightest endeavour to improve upon the old system of boiling as described in THE ARTIZAN of last month, until some years after the total abolition of slavery. In about the year 1845, however, Mr. Gadsden proposed an evaporating pan, in which the revolving cylinder above described, was replaced, by what might be termed a skeleton cylinder. It consisted of two metal discs, corresponding to the two ends of the cylinder, and connected together by a series of solid metal rods fixed at short distances round the periphery of each disc. By this means, the objection to the displacement was overcome, but unless it were driven at a very slow speed it had the disadvantage of frothing the liquor, and moreover, the steam jacket of the pan alone, afforded scarcely sufficient heating surface The Gadsden pan was afterwards improved by Mr. Wetzel, by substituting for the solid discs and rods, two hollow discs connected by pipes, as shown in Figs. 5 and 6, Plate 371. By this means, an ample amount of heating surface is obtained, and the film of liquor carried round by each pipe is kept hot, while being exposed to the air; the amount of evaporation thus obtained being very large. This description of pan has been very successful, and is now being very extensively adopted in nearly all sugar growing countries. In consequence of the large heating surface thus obtained, a very low pressure of steam is required to give sufficient heat, the exhaust steam from the mill engine being sometimes used for that purpose, and there is, therefore, no trouble with the steam joints.

Although the Wetzel pan answers the purpose for which it was designed very perfectly, several other modifications of the same system have been proposed, which have advantages peculiar to themselves, and are variously preferred by different manufacturers. The accompanying engraving, Fig. 10, illustrates a steam jacketted pan, invented, we believe

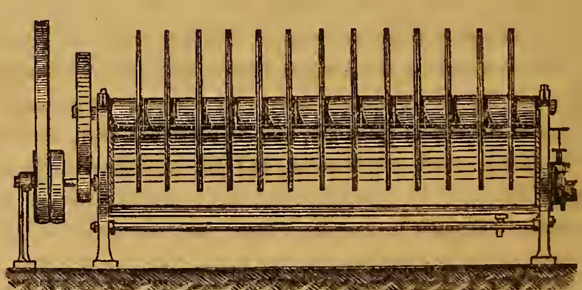


FIG. 10.

by Mr. Shroeder, which is fitted with a set of revolving discs strung upon a shaft, and kept about 6in. apart by means of washers, of that length, placed between them. It will be seen that this arrangement has the important advantage of freedom from churning or beating up the liquor, and also has the advantage of cheapness; but we have found it somewhat difficult to keep up sufficient heat without having a coil of steam piping running in a serpentine form between the discs, in addition to the steam jacket of the pan. These discs should be fitted on a square shaft, as the tendency to slip round the shaft, when the liquor gets thick is very great.

Another modification of this pan was proposed by Mr. Bour, of Mauritius, about the year 1854, and is illustrated in section in the

annexed engraving, Fig. 11. This plan consists in fitting a steam

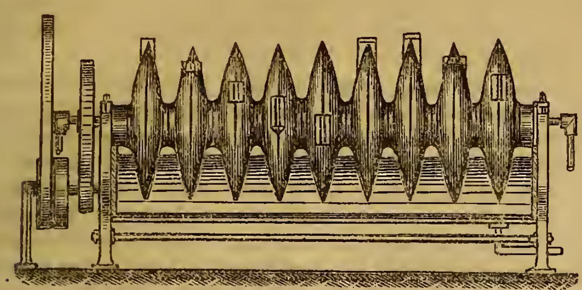


Fig. 11.

jacketted pan with a series of flat spherical discs, heated by steam, each disc being fitted with three cnps, placed equi-distantly npon its circumference. As the discs revolve, these cups dip into the liquor, and taking up a certain portion, discharge it over the heated surface of the discs when they arrive at the top. This description of pan has been found to answer very well, bnt we think it would perform still better if the cups were removed, as a film of the liquor would be constantly carried round in the samc mauner as in the Shroeder pan just described without churning up the liqnor. By this arrangement, also, a sufficient amount of heat is obtained withont the extra coil of pipes in the pan, which, as has been previonsly remarked, is objectionable in consequence of the difficulty of cleaning.

From the above remarks it will be observed that there are three descriptions of apparatus, viz., the Wetzel pan, the Shroeder pan, and the Bour pan, similar in principle, but somewhat different in their arrangement—either of which are well adapted to concentrate the liquor at a moderate heat. We may here mention that each of the three arrangements jnst described are commonly called "Wetzels" by the planters, and as the process of evaporation is similar in each of the three varieties we will adopt their nomenclatnre. The process of concentration is perfectly simple. The cane-juice after having been evaporated over a fire, in the battery, as above described, up to a density of 26° or 27° Beaumé, is drawn down into one of a series of Wetzel pans. The steam is then let on, and the driving gear set in motion, when the process of concentration immediately commences, and continnes without interruption and, until near the skipping point, without attention. This point, as we have already remarked when describing the old process of boiling, can only be correctly jndged by practice. We are of opinion, however, that in this case it is somewhat easier, as the crystals of sngar are much more distinct in conseqnence of the lower temperature of the liqnor; besides which there is in this case but little danger of over-boiling. The Wetzel pan shown in Figs. 5 and 6, (Plate 371), has lately been manufactured by Messrs. Walker, Henderson and Co. It is 9ft. 6in. long, and fitted with a revolving drum or "reel," having 22 tnbes 7ft. 6in. in length, and 2in. in diameter, revolving at a velocity of about 12 revolntions per minnte. This pan is calculated to concentrate 2 tons of sugar in 10 hours with ease.

(To be Continued.)

Launch of a Steamer at Liverpool.—The *Egypt*, a fine new screw steamer, intended for the National Steamship Company, was launched on the 15th nlt., from the yard of the Liverpool Shipbuilding Company. The vessel is 445ft. in length, 44ft. broad, and 36ft. deep from the open deck, her gross tonnage being 5,064 tons, and her net tonnage 3,443 tons. The engines are on the compound principle, and will indicate over 3,000 horse-power. She has four decks, is divided into seven water-tight compartments, and is fitted up in every department with the utmost completeness. She will be provided with no fewer than ten lifeboats, with patent lowering apparatus. The *Egypt* is said to be the largest steamer yet built at Liverpool.

ROLLING AND SWING BRIDGES.

It not nnfrequently occurs that it is required to erect a bridge across a river, or estnary, where the conditions of the locality render it necessary that a portion of the bridge should admit of being opened, or temporarily removed, in order that shipping may pass it; and the construction of snch a bridge calls for the most careful consideration, both in the designing and execntion of the work; hence we propose to offer a few remarks on the principles of these structures, such remarks being chiefly of a practical character.

There are several ways in which a bridge may be opened: thus the roadway may be withdrawn or rolled backward towards the land, or it may be caused to revolve upon a centre, thus altering its position from being at right angles to the direction of the stream for one parallel to the same, or it may be caused to rise vertically abont a centre fixed upon the pier. Of these three classes of bridges the first is termed a rolling bridge, the second a swing bridge, and the third a bascule bridge; and the qnestion to be determined is, which description of structure is best snited for the work set out for it.

The desiderata in opening bridges are—durability of parts, rapidity in opening and closing the bridge, and minimum of force required to effect the same. The importance of the first point is rendered more distinct by comparing an opening bridge with one which is permanent in its position. In the former case it is usually absolutely necessary that the bridge should dnring certain periods in the day be open, to allow the continnance of traffic on the river or estnary which it spans; hence if the working gear be out of order, so that the strncture cannot be readily opened and closed, it must be kept open until it is again in a position to work with ease: therefore while undergoing repairs it is useless as a bridge, if those repairs are being made npon the moving gear. Rapidity in opening and closing the structure is very necessary, in order to reduce the loss of time due to stoppage of traffic to a minimum, for it must constantly occur that either the land traffic is stopped to accommodate that on the water, or *vice versâ*.

The third requirement refers to the amount of force requisite to pnt, and maintain, the bridge in motion while opening and closing, and, as a matter of course, the less power reqnired the simpler will the machinery be, the cost of working and wear and tear being proportionately small, hence the liability to derangement of the working parts are also small.

We will now proceed to consider *seriatim* the different descriptions of opening bridges to which we have above referred, commencing with the rolling bridge.

The rolling span of an opening bridge is so arranged, that when requisite, it can be wheeled or rolled back in a line parallel to the direction of the length of the bridge, so as to pass over or under another portion of the structure, or on to the land, thns leaving the space clear which it occupied when resting on its piers, and doing duty as a bridge. In such cases, the structure will usually be made to move upon four or more rollers, two of which are fixed to the shore end of the rolling girder, and like ordinary carriage wheels travel npon rails, while the others are snpported in fixed frames or pedestals, the girders of the bridge resting upon them, and passing over them while rolling back and forward. To this description of strncture there are many very grave objections, objections which theory will fail to discover, although after they are rendered conspicuous by practical experience, the defects giving rise to them may be accounted for by reasoning on the conditions under which these masses of matter are required to be put into motion. In the first placc, it will be observed, that there is a very great load on each roller, especially when we find only four rollers to snstain the entire weight of the bridge. Assume for instance, snch a work to weigh about 100 tons, which would correspond for a railway bridge to abont a 70ft. span, then there will be 25 tons weight on each roller carrying the bridge, and from the form of the bridge and its mode of motion, its progress is necessarily unsteady from its own vibration which is increased by any inequalities

of the surface upon which it runs, and also by starting or jerking of the propelling machinery.

As we have above stated, a part of the bridge must be allowed to rest on rollers in fixed pedestals, hence, the lower surfaces of the bottom flanges of the girders are those upon which the rollers revolve, and any unevenness in such surfaces, must very materially add to the amount of force required to keep the structure in motion, and if the flange be curved it will of necessity involve the addition of extra force, either when opening or shutting, to propel it up the incline, produced by its own curvature. Moreover, a brief consideration will show us that such a curvature in the girders of a bridge, cannot possibly be avoided, for if we make the bridge with a dead plane surface to its bottom flanges, it will deflect with its own weight, and even if we allow for the sake of argument, that the bridge could be made with such a "camber" that its own weight will exactly bring it down to a straight line when on its bearings, then again whilst in the act of rolling its deflection would vary, for the distances of the points of support mnst vary, the rollers supporting the ends of the girders, being fixed to, and travelling with it, whilst the others retain their positions, in relation to the fixed piers, so that when the rolling span is first started from its fixed bearings it has a long overhang, and there is a short distance or length of span between the fixed and travelling rollers, then as the bridge progresses in opening, this length of span increases, accompanied by the decrease of overhang, and a corresponding change occurs in the form of the girder. A similar but obverse change of form occurs in closing the bridge. This then shows that there is a canse which cannot be obviated, always giving rise to excessive resistance to motion on the part of rolling bridges, which we may observe, is much aggravated by the changes produced in a bridge, by the vibratory effects of passing loads, and more especially of railway trains. The extent to which these disturbing causes affect rolling bridges, may appear somewhat astonishing to those who have not been much acquainted with them in a practical sense, but when we observe, serious mistakes in calculations connected with such matters, we look closely for the causes, and they often lie nearer the surface than might have been anticipated To bring the matter more clearly forward, we will have recourse to figures obtained from actual trials. The first point to be determined is the amount of tractive force required to move the bridge, here it might seem that railway practice should furnish us with the requisite data, but to be on the safe side, we will allow a tractive force of twenty pounds per ton of load; then for this we have, taking the rolling span of the bridge as weighing 100 tons—

$$100 \times 20 = 2{,}000 \text{ pounds}$$

or, say roughly, one ton. This wonld be moderate enongh, but we find in practice it sometimes requires three or four times as much, and in one instance there was actnally six times the calculated tractive force applied to a rolling bridge before it would move, and then it went but slowly and spasmodically, notwithstanding that the bridge was well constructed and carefully erected. The excess of force requisite to propel the bridge was of course absorbed in overcoming those obstacles to motion to which we have referred above.

Under these circumstances it would seem that where they can be avoided it is exceedingly nnwise to construct a rolling bridge, there being so many objections to it; but, of course, where the only available room lies in the line of the bridge, there is no option, and this class of work must be had recourse to.

The next bridge to which we shall refer is that on the "bascule" principle, being that which opens upward, as it were, like a box lid on hinges. This kind of structnro answers passably well for small light spans, but when large is objectionable on account of the power reqnired to raise the weight, and also on account of the resistance of the wind to any opposite movement of a large surface against it.

The last arrangement to which we desire to call attention is that which has given the greatest satisfaction in practice, viz., the swing bridge, which opens by turning sideways, moving from its normal position across the stream to one parallel, or nearly so, to its direction. In this arrangement the bridge revolves npon a turntable similar in construction to those used on railways, and is of course properly balanced, so that its weight may be dnly distributed on the working parts of the turntable.

By adopting the swing bridge, we avoid those great resistances to movement which are so fatal to the practical utility of the rolling bridge, there is no tractive force required to produce actual removal of any portion of the structure, in the strict sense of the term; for the centre of gravity of the opening span, or swing portion of the bridge, remains unmoved. It is located if properly balanced, in the centre of the turntable when the bridge is closed, and it occnpies the same position when it is opened, there has conseqnently been no actnal transference of weight from one site to another, and the only resistance which has to be overcome, is that dne to the friction of the rollers in the turntable, and the centre upon which the bridge rests; and that this may be reduced to a minimum is evident, from the fact, that at the present time, there are many turntables in actual use, which, when loaded with sixty tons, in addition to their own weight, are easily caused to revolve by one man acting at a distance of 25ft. from the centre. Thus, it is evident that by improving the turntable of swing bridges, we may fairly anticipate getting a structure as perfect as is practically possible to employ, where it is necessary that a bridge should open and shut; and in this direction, we should strongly advise those contemplating the erection of such works, to turn their thoughts, as the rolling bridge has in every case in which it has been nsed, proved a comparative failure, whereas, swing bridges have generally served their purpose well, and the snperiority of the latter, evidently, does not rest upon perfection of workmanship, but is dne to accuracy of principle.

A NEW PNEUMATIC TUBE.

On 29th January, a number of gentlemen were present by invitation at the General Post Office to witness the working of a pneumatic tnbe which has been laid down by Messrs. Siemens, in connection with the Telegraph Department, and for which the arrangements, as far as this country is concerned, are entirely novel. The current through the tnbe is always in the same direction, and the tube, being bent npon itself, and carried back to its starting point, furnishes what may be called an np and down line for despatch in either direction between its termini or intermediate stations.

The principal object of pneumatic tnbe communication is to do away with the necessity for the transmission by wire of telegraphic messages which arrive at the central station of a large city, and which are to be delivered in some snburb or distant part. For example, a message arriving from Edinburgh at Telegraph-street for delivery in Whitehall would at one time have been re-transmitted by wire from Telegraph-street to the station at Charing-cross, and sent ont thence by a messenger. This system occnpied considerable time, employed a large number of clerks and instrnments, involved the construction and maintenance of an intricate system of intra-metropolitan wires, and doubled the risk of errors in transmission. Under the new arrangement the message will be once for all transcribed upon the official form at Telegraph-street; and this form, shot through the tube to Charing-cross, will there be taken out, placed in an envelope, and instantly despatched. The illustration is at this moment not perfectly trne to the facts, since the tnbe does not yet extend to Charing-cross, but it will do so in the course of a very short time, and will also be carried on to Parliament-street and the House of Commons. At present the tube starts from Telegraph-street, passes through the office at St. Martin's-le-Grand, and thence to Temple-bar, where it makes a complete bond, and returns to Telegraph-street by the side of its outward course. In the office at St. Martin's-le-Grand there are, therefore, two tnbes, or rather two portions of the same tube, in one of which the conrse of traffic is westward to Temple-bar; in the other, eastward to Telegraph-streot. It would be equally practicable to make the tube describe a circuit instead of returning through the offices by which it gocs forth.

The tubo now working is of wrought iron 3in. in diameter in the clear, and the despatches are contained in guttapercha cylinders covered with felt, and fitting tho tnbo accurately by means of a felt wad at the closed end. These cylinders, which are called "carriers," are abont 8 or 9in. long, and the cnrves of the tube must be on radii of sufficient length to

permit the carriers to pass easily. At each intermediate station there is a so-called shunting apparatus, by means of which carriers can be introduced or withdrawn. At a shunt, the main tube is cut for a length of about 2ft., and the gap can be filled either by a piece of similar tnbe furnished with a little outside bell, acted upon by a stud within, or by a sort of cage, furnished at one end with a perforated plate to stop a carrier, and with a glazed lid, through which the carrier may be seen. Both the short piece of tnbe and the cage are accurately ground at their extremities, so as to make an air-tight joint with the cut surfaces of the main tube; and they are attached to the same lever, a single movement of which fills the gap either with the short, permeable tube or with the intercepting cage. The whole apparatus is worked on a block system by telegraphic signals. Let us snppose that Telegraph-street has a carrier for Temple-bar. It being signalled that the line is clear, and the officials all through knowing what is abont to be done, the short permeable tnbe would be left in position at St. Martin's-le-Grand. The carrier, passing through unchecked, would, nevertheless, touch the stud inside the short tube, and would ring the bell as it did so. The line from Telegraph-street as far as St. Martin's-le-Grand would then be clear, and a signal to this effect would be sent back. Telegraph-street might have its next carrier for St. Martin's-le-Grand, and, on this being signalled, the short permeable tnbe wonld be replaced by the intercepting cage. On entering this the carrier would be stopped by the perforated plate, and, the lever being again moved, the cage would be taken out, so that the carrier could be withdrawn from it. The solid portion of the intercepting plate serves, of course, to interrupt the cnrrent of air through the tube, but this difficnlty is met by throwing out a loop or arch of copper pipe from one end of the gap in the main tube to the other. The calibre of this pipe is eqnal to the surface of the solid portion of the intercepting plate, and when the cage is moved into the line of the main tube, a commnnication between this and the copper pipe is also opened.

The time occupied, at tbe trial, in the passage of a carrier from Telegraph-street to St. Martin's-le-Grand, a distance of 852 yards, was one minute and 40 seconds, and the time from Telegraph-street to Temple-bar, a distance of 2,058 yards, was four minutes; the tnbes being worked both by pressure and vacuum. When worked by vacuum only the time required is usually about one-third more. This rate is considered highly satisfactory.

The new system was bronght before Mr. Scndamore by Mr. Siemens about four years ago; but its execntion was delayed pending the acquisition of the telegraphs by the Post Office. In order to carry it into complete operation, it would be necessary to divide the metropolis into a certain number of main circuits of 4in. tnbe, to connect the principal Post-offices with one another, and into a much larger number of branch circuits of 3in. tube, to connect the principal Post-offices with branch offices in all parts of the town. The carrying power of the tubes, arranged on a circular system, is such that it would suffice for the transmission of telegrams and letters throughout London with a certainty and despatch that could not be attained in any other way. Carriers might leave each station every five minutes throughout the day, and the letters contained in them, on being received at the principal offices, could be sorted and forwarded in other carriers to branch offices near their destination, so as to be delivered within half an hour of their being posted.

THE SCREW STARTER OF HER MAJESTY'S SHIP "MONARCH,"

The hydrostatic engines introduced on board ship by Admiral Inglefield, are gradually taking their place as a part of the requisite appliances for first-class men-of-war. The difficulty of steering our ponderons iron-clads, the number of men, often 40 to 50, reqnired to get the rndder over when the vessel is at full speed, and the imperative necessity in naval actions of protecting the steering gear, insuring the turning of the ship within circles of limited dimensions, and within equally restricted periods of time, gave rise to devices for mechanical means possessing more certainty and facility than collective human power afforded. To this end steam steering-gear has been fitted to several ships, and offers sensible advantages.

Bnt an even more valuable auxiliary was close at hand, which for years had been overlooked and never utilised, Our large naval ships, drawing from 20 to 30ft. of water, have a very large amount of pressure exerted against the lower parts of their hnlls, and this hydrostatic power Admiral Inglefield proposed to ntilise as a mechanical force for actuating their steering-gear. Such apparatus was first fitted to her Majesty's ship *Achilles*, and afterwards in an improved form to the Turkish iron-clad *Fethi Bulend*. Successfnl for its power, certainty, and ease of action on the rudder, it was soon seen that this hydrostatic force was applicable for other purposes of a temporary and intermittent character; and calculations were gone into to show that turrets weighing 300 tons could be turned round their entire circnmference in three-quarters of a minute, quite as fast, perhaps, as their serious momentum would properly permit.

One of the great inconveniences in screw vessels when sailing is the dragging of the propeller. There are other obstructions and difficulties encountered in navigating, and which are only to be got rid of by a temporary application of force. Steam cannot be expected to be constantly maintained against every emergency, and, indeed, is not always available. The hydrostatic pressure is always at hand, and requires no lighting of fires or any other preparation. It is not only ever present, but economic. It has only to be applied when required, and the waste water discharged into the bilge can be pumped out at any convenient opportunity. When Admiral Sir Spencer Robinson, the late Comptroller of the Navy, accompanied the cruise of the Channel fleet last year, he had practical evidence of some of these difficulties, especially with the propellers of the *Monarch*, and on his return he suggested to Admiral Inglefield to devise a plan for a hydrostatic engine for turning the screw of that vessel when disconnected from the engines. On one occasion the *Monarch* was for two hours and a half nnable to wear, the helm all the time being hard up, but the propeller happening to be in a position contrary to the action of the rudder. Again, when the screw-shaft has been some time at rest it cannot be started unless a considerable speed has been got upon the ship, not, indeed, less than five or six knots; bnt once started, the screw would continue to revolve until the ship's speed had fallen to about three knots. Indeed, every practical sailor will be very well aware of the immense advantage of being able to start the end of the screw-shaft into motion or to continue it in action under occasional circumstances for a short period.

Steam was in this case, as well as in the former for steering, first considered, and a steam-engine made for the purpose for the *Achilles* or the *Agincourt*. But the limited space in the screw-alley prevented its ever being nsed, and it now lies, we believe, in one of her Majesty's dockyards. Nothing more, however, was done in this direction until the necessity for some special arrangement had made itself officially evident in the *Monarch*.

The apparatus proposed by Admiral Inglefield had been manufactured at the works of Messrs. Kittoe and Brotherhood, in Clerkenwell, and was a short time ago tested in the presence of the Admiralty engineer, Mr. Wright, Admiral Frederick, Admiral Inglefield, Admiral Halstead, Captain Hoseason, Captain Heath, and other practical officers and engineers. The hydrostatic pressure required was artificially supplied by a tank of water erected at an elevation of 20ft.—a height equivalent to the draught of water of the *Monarch*, and which gives an hydrostatic pressure of 9¾lbs. per square inch.

The machine is very simple and compact in its arrangement and action. It consists of an hydraulic cylinder, to be placed on the keel of the ship, with a piston and rod, very much after the manner of the ordinary steam cylinder. Into this the water will be admitted in the ship through a Kingston valve. The diameter of the cylinder is 30in.; the length of stroke 12in., and the machine capable of making from 18 to 20 strokes a minnte. To the piston-rod of this cylinder is attached a plunger pump of the diameter of 3in., thus giving an accumulated force in the pump of say 100 times the pressure in the working cylinder, or equal to 1,000 pounds on the square inch. The water is conveyed from a chamber snrrounding the pump by a pipe to a 4in. hydraulic ram attached to the end of the lever of a ratchet-brace, the ratchet-wheel of which is keyed fast to the stern-shaft of the propeller. There is a valve box attached to the ram cylinder which is actnated by a pin in the ratchet-lever to which is connected a rod working the valve, and thns cansing a continnous action of the ram as long as the water pressure is permitted to act. When the screw is started into motion the ratchet-wheel runs away from the pawl, and leaves it behind in its revolutions. To prevent the clicking noise under such circumstances, and to guard against accidents to the gear when the ship's main steam-engines are started, the pawl is lifted ont of the way and secured by a pin specially provided for the purpose. The joints in the hydraulic pipes are exceedingly well made, upon a patented principle. The two ends are merely placed together and secured by a nut, packed with an indiarnbber ring, which pressed npon by the water packs the joint as close and as tight as in the case of the leather packing in an hydraulic ram gland. These joints are parts of the highest merit, as one of the great difficulties to be overcome in the application of the hydrostatic machines has been that of securing good connections in fitting the apparatus so low in the hull, and in making perfect the orifices where the pipes have to pass through bnlkheads.

During the testing of the machine the pressure gange steadily registered 1,000lb, to the inch, and was brought to a standstill at very considerably higher pressure when the discharge cock was shnt off. Under this pressure the whole machine and its accessories were perfectly tight, no "weeping" at any of the points, nor a "tear" anywhere to be discovered.

The valne of snch a power, always ready as soon as the Kingston valve is opened, for any work, steering, turning turrets or screw shafts, raising guns, or, in ships provided with the proper wells, raising the screw bodily, is scarcely to be overrated. In the last operation very nearly the whole ship's company is commonly employed on the old plan of raising by tackle.

Altogether both Admiral Inglefield and the mannfacturers may be complimented upon this excellent piece of engineering.

LONDON INTERNATIONAL EXHIBITION, 1871.

The buildings in which this will be held are now finished, and ready to receive the exhibits. They will accommodate altogether 50,000 persons. The object of the Commissioners in holding the Exhibition may be summed up as follows :—They propose, in the first place, to make an International Exhibition a permanent institution of the country, giving to industrial art the same opportunity that is afforded to fine art by the annual exhibitions of the Royal Academy. In the second place, they produce the area over which the exhibition shall spread itself, by redncing the various industries into groups, and taking certain of these each year, bring the entire indnstry of the country under review every seven or eight years, fine art being a standing division of the programme. And, in the third place, to restrict the conditions under which exhibits have hitherto been received, by making all articles nndergo a preliminary sifting, through appointed committees of selection, thus excluding all works that do not possess sufficient artistic merit to warrant their exhibition, and by the fnrther exclusion of mere masses of natural products. The manufactures exhibited this year will be woollens and pottery, in addition to fine art of every description. H.R.H. the Prince of Wales is the president of Her Majesty's Commissioners for the Exhibition; Messrs. Spiers and Pond are to be the refreshment contractors; Messrs. Chaplin and Horne the carriers; and Her Majesty's Commissioners have entered into arrangements for the printing and pnblication of the official catalogues by Messrs. J. M. Johnson and Sons, of Castle Street, Holborn, London.

FOREIGN TRADE OF CANADA.

The *Toronto Globe* says :—We have often called attention to the advantages of trading directly with South America, the West Indies, and other more distant regions, instead of allowing our friends over the lines to be the general carriers to those conntries of the products of Canada, and thus to reap a handsome profit, which might quite as well go into the pockets of Canadians. The abolition of the Reciprocity Treaty we felt certain would contribute very materially to this much-to-be-desired object, and we are glad to say that every year's experience goes to confirm the anticipation. In the valley of the Ottawa alone the lumber traffic employs 50,000 men and 15,000 horses, and yet this forms bnt a part of the vast lnmbering operations of Canada. The Eastern States import every year many millions of our lumber, not merely for their own nse, but in order to re-export it. They find that, in spite of the dnty, it pays them to mannfacture Canadian lumber in different ways, and send it to South America, the West Indies, Anstralia, and Africa. In all these countries lnmber is scarce, and commands what we should regard as fabulous prices. Canadian merchants never attempted to compete for this trade till 1864-5. Before the former of these years not a vessel went directly from Canada on such enterprises; during last season some 60 or 70 were so employed. In pnshing this trade new markets will be opened up for other Canadian products. A beginning has been made in this direction, bnt little more. During last season upwards of 200,000,000 cubic feet of timber were sent from Canada to Europe, and more than three times that quantity to the States, while 25,000,000 were sent to La Plata, 1,700,000 to Australia, 2,000,000 to Valparaiso, and 39,768 sugar boxes to Cuba. We have no means of determining how much of what was sent to the States was re-exported, but the amount mnst have been very great, and a great part of it might quite as well have gone to its destination from Canada, after affording our merchants a profit in preparing it for those markets by manufacturing it into window-sashes, doors, flooring, &c. What is true of the lumber traffic is equally so of that in flour and other commodities; and return cargoes, in the shape of tropical products, will every year find a larger and readier market among ourselves. We are glad to see that, though the Government has not followed up the report made by its Commissioners a few years ago, the merchants of Canada are gradnally pushing their way to what we hope in some years more will be a very large and profitable branch of trade. If it pays the Americans to buy our lumber, even though the duty is 20 per cent., and then to manufacture and export it to foreign countries, it ought surely to pay us to take the manufactured article *minus* the 20 per cent. to common markets, and there to compete with onr sharp consins on equal terms. Five years ago the trade of which we speak had no existence; five years hence, we make bold to prophesy, will see it reach, if no unforeseen calamity happen, what would now be regarded as gigantic dimensions.

POSTAL TELEGRAPHS.

The Queen's speech was transmitted by Postal Telegraph to nearly 200 towns in the United Kingdom. The speech contained 1,780 words;—that is more than double the number of words contained in the speech of 1870. The transmission commenced immediately after the commencement of the delivery of the speech, at 2 19 p.m. Opportunity was taken to test the powers of the various instruments employed by the Post Office for the transmission of messages. For the transmission to Brighton, Southampton, Portsmouth, and some other towns the Morse printing instrument was employed. The transmission to Brighton was completed in 43½ minutes, the transmission to Southampton in 45 minutes. The operators in these two cases were women, and it is believed that the speed which they attained of over 40 words per minute is the greatest that has ever been obtained for an equal length of time on the Morse printer. As an experiment the speech was transmitted to Liverpool by the Hughes type printing instrument, which prints its messages in ordinary Roman type. The speed attained was between 36 and 37 words per minnte, and as in working this instrument abbreviations are not used, the speed may be considered fully equal, if not superior, to the Morse, on which abbreviations are used. For the transmission to all the principal towns in the country the Wheatstone automatic transmitter was employed. Messages for transmission by this instrument are, it is well known, pnnched out on a separate instrument, the punched ribands being afterwards passed throngh the transmitter. By the employment of additional punchers at one end and additional writers out at the other end, the preparation and writing out of the message are made to keep pace with the transmission. The speed attained varied with the length and quality of the wires employed. The highest speed attained was to Bradford, to which place the speech was sent at the rate of 94 words per minute. The speech, as transmitted by telegraph, was sold in Newcastle and Edinburgh at 3 45, in Dnblin at 3 47, in Glasgow at 3 50, in Cork at 4, in Jersey, with two transmissions, at 4; at Darlington, with two transmissions, 2 minntes past 4; in Dundee, with two transmissions, at 4 20; in Belfast, with two transmissions, at 4 28; in Inverness, with two transmissions, at 4 40; and in the Isle of Man, with two transmissions, at 5 p.m. The length of the riband punched for the Wheatstone transmitter was upwards of 111 yards for a single copy of the message. This is the first occasion on which a message of this kind has been transmitted on the Wheatstone automatic instrument.

SOCIETY OF ARTS.

ON A METHOD OF LIGHTING TOWNS, FACTORIES, OR PRIVATE HOUSES, BY MEANS OF VEGETABLE OR MINERAL OILS.

By A. M. Silber, Esq.

(*Continued from page* 34.)

Cost of Production of the Petroleum Light.

In determining the illuminating power of the different lights which it is my pleasnre to exhibit to you this evening, I was fortunate in securing the help of Mr. W. Valentin, principal assistant in the Royal College of Chemistry, a gentleman who has had mnch experience in testing gas, and who gave me mnch valuable advice in elaborating the new system of lighting. I submitted two lamps for burning colza oil, and four lamps constructed for the consumption of petroleum, to that gentleman, together with the experimental model which you see here. The experiments were made at the Royal College of Chemistry. The illuminating power was taken by means of the well known Bunsen photometer, and is expressed, as is usual in this conntry, in sperm candles, consuming 120 grains of sperm per hour. Each experiment extended over at least three hours, so as to counteract any slight error arising from the drawing off of the oil. The amonnt of oil consumed was carefnlly ascertained by weighing before and after each experiment. Petroleum oil of specific gravity ·795, was employed, one gallon of oil weighing 55,650 grains. The oil distilled between 340 deg. to 350 deg. F. It can be obtained wholesale at 1s. 6d. per gallon.

Mr. Valentin has tabulated the resnlts, and has, for better comparison, given in column 1 the number of sperm candles; in column 2 the nnmber of cubic feet of common coal gas, price 3s. 9d. per 1,000 cubic

feet; in column 3 is given the hourly consumption of oil in grains; in column 4, the cost of oil consumed per week; in column 5, the cost of a corresponding amount of coal gas per week; and lastly, in column 6, the proportional cost of gas and oil.

The illuminating power of common London coal gas has been taken at 15 sperm candles for every five cubic feet of gas burnt, although it is a well-known fact that the consumers' gas burners probably never burn the gas to equal advantage, and that 12 sperm candles may be said to represent the consumers' light more truly than 15; and that consequently my petroleum lights are 20 per cent. cheaper, in addition to the percentage shown in the tables. It is also a well-established fact that gas-burners consuming less than five cubic feet of gas per hour, such as the ordinary fish-tail burners most generally in use, do not produce a proportionate illuminating power, whilst on the other hand, gas-burners consuming more than five cubic feet of gas give a proportionately better light. The pressure under which gas issues from the burners likewise affects its illuminating power most seriously.

For these and other reasons, to which I need not refer, such as differences in the burners themselves, &c., I have abstained from comparing with coal gas the smaller lights, giving less than 15 candles, and likewise the larger lights, giving considerably more than an ordinary 5ft. jet-burner, and I prefer to rely, for the comparative numbers which I beg to submit to you, upon the petroleum lights which give a light equal to about 12 to 20 sperm candles.

I have already stated that the earlier experiments revealed certain defects in my burners, which, fortunately, I was able to rectify, and the Table which embodies Mr. Valentin's experiments shows, therefore, a somewhat greater cost on the side of petroleum compared with that of gas (say from 10 to 20 per cent.), which I think would, however, be fully neutralised by the 20 per cent. loss of illuminating power which the consumer suffers on account of having to employ less perfect gas burners, so that even these earlier experiments, set forth in the accompanying Table, exhibited most encouraging results:—

room, I may say that the lights are 40 to 50 per cent. cheaper than coal gas.

Hitherto, I had only experimented with argand burners. I next directed my attention to flat light, which can be trimmed so much more readily. I felt that it would be desirable to obtain small lights, giving about 4 to 10 candles illuminating power. I burnt the same petroleum oil in four different lamps, which you see before you, and determined the illuminating power of the light they produced. I next placed the same flat wick burners in a wick case, which could be screwed to my model, and determined the light again, when an increased illuminating power of 15 to 20 per cent. was obtained. Table III. contains the photometrical results

There can be no doubt that flat lights possess certain advantages over round or argand lights, especially on account of the greater facility with which they can be trimmed; but it is impossible to obtain from them the same intense light, owing no doubt to imperfections in the chimneys. I therefore give the preference to argand burners.

The cost of a flat light, taking Table No. III. for comparison, giving about 16 candles, is about the same, or slightly less than that produced by coal gas.

There remains now for me only to show you an ordinary table or study-lamp of novel and perfectly safe construction, which gives a remarkably good light. I have not had time to ascertain photometrically what amount of light it gives, nor what its cost of consumption will be, compared with gas-light; but as I use the same size burner and same wick as in No. 1 burner, described in Table II., giving the light of 23·24 candles, it promises to give a light which is cheaper than gas. This lamp promises also to become a useful adjunct to the microscope and spectroscope, as Mr. Highley, of No. 10A, Great Portland-street, assures me.

I have constructed, with the assistance of Mr. White, a railway lamp, which you see before you, both for rape and petroleum oil, giving the light of eight candles for rape oil, and six and a-half candles for petroleum,

TABLE 1.

SHOWING ILLUMINATING POWER OF ORIGINAL ARGAND BURNERS, CONSUMING COLZA AND PETROLEUM OIL.

DESCRIPTION OF LAMP. (Argand Burners.)	Illuminating power expressed in sperm candles.	Illuminating power expressed in cubic feet of common coal gas = 15 candles.	Hourly consumption of oil in grains.	Cost of oil for one week's consumption of 42 hours.	Cost of gas at 3s. 9d. per 1,000 cubic feet, for one week's consumption of 42 hours.	Proportional cost of gas and oil.
Colza Oil Lights.				s. d.	d.	
Lamp 1, consuming colza oil from an Argand burner, wick $\frac{7}{8}$ to $\frac{15}{16}$ of an inch	11·81	...	1,203	2 9$\frac{1}{5}$	...	...
Lamp 2, with imperfect chimney, wick 1$\frac{1}{4}$	3·98	...	532	1 2$\frac{2}{3}$	...	...
Ditto, with differently constructed chimney	15·01	5	1,775	4 1	9·45	1 : 5·2
Petroleum Oil Lights, as originally constructed.						
No. 1 Burner, size of wick $\frac{7}{8}$ to $\frac{15}{16}$ of an inch	15·67	5·22	864	0 11·8	9·86	1 : 1·21
Ditto Ditto Ditto	15·47	5·15	787	0 10·7	9·73	1 : 1·11
No. 2 Burner, size of wick same (of French constrnction)	14·93	4·98	818	0 11·1	9·4	1 : 1·18
No. 3 Bnrner, size of wick 1$\frac{1}{4}$ of an iuch	17·01	5·67	818	0 11·1	10·7	1 : 1·04
No. 4 Burner, size of wick 1$\frac{1}{2}$ of an inch	33·85	...	2,145	2 5	...	...
No. 5 Burner, size of wick 1$\frac{3}{4}$ of an inch	38·32	...	3,433	3 10$\frac{2}{3}$	...	...

Lights ranging from 15 to 38 sperm candles, of greater intensity than any other lights, promised sufficiently well to induce me to pursue the subject with every prospect of success, and when I again tested the lights, altered as the burners were in the meantime, I had the gratification to find that the illuminating power produced by the same burner was 40 to 50 per cent. greater than before. Table II. gives the results, before and after the alteration, of the burners.

I have already explained that the alterations in the burners consisted mainly in the lowering of the oil level in the wick tube. The same lights which hitherto had produced 15 candles gave now 21·5 to 23 sperm candles, without any increased consumption of oil, so that an increased illuminating power, to the extent of 40 to 50 per cent., was secured by this simple alteration, whereby the new petroleum lights compare now much more favourably with gas-light, rendering them in fact 20 to 30 per cent. cheaper than common coal gas, and if we take into account that at least 20 per cent. less illuminating power is produced from the consumers' ~~burners than what can be produced in the gas-testing~~

and the lights of which can be decreased or increased at will. I am not aware that petroleum has ever been burnt in railway lamps, although repeated efforts have been made. This lamp is a perfect success. It may be swung about in all directions without discharging any oil, and can be made to burn for twenty or more hours without requiring any attention. It also offers the advantage that the oil is placed in that part of the lamp which is above the outside roof of the carriage. The Board of Directors of the Great Western Railway, who warmly received my propositions for lighting up railway carriages, gave me every facility of practically testing the new lamp. It was placed in the guard's van of a night express train, and travelled all the way to Chester and back again, giving a perfectly steady light. The inspector testified to the above in a memorandum to me. I am also in treaty now with other companies.

I have not been able to ascertain the consumption of petroleum, but it is not difficult to foresee a considerable saving upon the railway lights, ~~which consume vegetable oils, such as rape or linseed,~~ if we glance at

the relative proportion of the cost of colza oil and petroleum, when consumed from my new argand burners as set forth in Table I. Colza oil costs four to five times as much as gas, consequently there would be a saving of from 500 to 600 per cent. with the new lamp, whilst double or treble the amount of light can be obtained if it be desired, which, I believe, will be hailed as a great boon by all night travellers on our great railway lines.

I may mention that the new burner can be readily placed in the railway lamps now in use wlthout any material alterations, and that it requires very little trimming. I have burnt it for 22 consecutive hours without ever touching it. It can be turned off like a street lamp.

To show the practicability of my novel mode of conveying oils to burners, I have had constructed a chandelier, burning from one arm colza oil, from the other petroleum, and from the third coal gas, and have had it burning for weeks in my office with perfect success.

I may also mention that Sir Frederick Arrow, accompanied by the elder brethren of the Trinity-house, came to my office to examine the new lights, at the instance of Dr. Tyndall, who was highly pleased with them, and who wonld no donbt have been here this evening if he had not been called away to the shores of Northern Africa, to study the grand phenomenon of a total eclipse of the sun, and that I am commissioned to prepare burner for lighthouse purposes, for which I believe these lights of great intensity are specially adapted.

Now, gentlemen, the lights which I have had an opportunity of exhibiting to you this evening are merely in their infancy; many shortcomings, of which I am even now aware, I have been unable to remedy as yet, especially those connected with chimneys. I have not been able either to test various kinds of oil, either vegetable, animal, or mineral. What the infant will become when it grows into manhood I am unable to predict. This much I may say, however, even now, that the child promises well, and that it has already distanced its elder brethren, candles, lamps, and gas-light.

TABLE II.

Showing Illuminating Power of Altered Argand Burners, consuming Petroleum Oil, as Compared with Original Burners.

DESCRIPTION OF LAMP. (Argand Burners.)	Illuminating power expressed in sperm candles.	Illuminating power expressed in cubic feet of common coal gas = 15 candles	Hourly consumption of oil in grains.	Cost of oil for one week's consumption of 42 hours.	Cost of gas at 3s. 9d. per 1,000 cubic feet for one week's consumption of 42 hours.	Proportional cost of gas and oil.
				s. d.	s. d.	
No. 1A Burner, wick	14	4·66	602	0 8·18	0 8·8	1 : 0·93
No. 1 Burner (original), wick ⅞ to 15/16	15·67	5·22	864	0 11·8	0 9·86	1 : 1·21
Ditto 2nd experiment	15·47	5·15	787	0 10·7	0 9·73	1 : 1·11
Ditto (altered)	23·24	7·74	795	0 10·8	1 2·63	1 : 0·738*
No. 2 Burner (original), same size as No. 1 (of French construction)	14·93	4·98	818	0 11·1	0 9·4	1 : 1·18
Ditto (altered)	21·52	7·17	788	0 10·7	1 1·55	1 : 0·79†
No. 3 Burner (original), wick 1¼	17·01	5·67	818	0 11·1	0 10·7	1 : 1·04
Ditto (altered)	28·0	9·33	1,102	1 3	1 5·6	1 : ·85
No. 4 Burner (original), wick 1½	33·85	...	2,145	...	...	...
Ditto (altered)	46·5	...	2,008	...	...	...
No. 5 Burner (original), wick 1¾	38.32	...	3,433	...	...	...
Ditto (altered)	50	...	1,965	...	...	...

* 35 per cent. cheaper than gas. † 27 per cent. cheaper than gas.

You see before you a street lamp, which is constructed on a similar principle to the railway lamp, and in which small or large lights may be burned with equal snccess. The mode of conveying the petroleum or rape oil to the burner from the oil reservoir round the upper rim of the lamp ensures a perfectly steady supply, and the oil is consumed in the most economical manner possible. I am this evening burning No. 4 flat burner, which gives the light of about 21 candles. It will, of course, be necessary to await the results of further practical testings in the open air before it can be said with certainty how it will turn out.

I may claim for the lights—

1. A perfectly regular supply of oil to the wick.

TABLE III.

Showing Illuminating Power of Flat-wick Burners, placed in ordinary Stand Lamps or Screwed to the Model.

DESCRIPTION OF LAMP. (Flat burner.)	Illuminating power expressed in sperm candles.	Illuminating power expressed in cubic feet of common coal gas = 15 sperm candles.	Hourly consumption of oil in grains.	Cost of oil for one week's consumption of 42 hours.	Cost of gas at 3s. 9d. per 1,000 cubic feet for one week's consumption of 42 hours.	Proportional cost of gas and oil.
				d.	s. d.	
No. 1. Flat wick, in lamp	3·56	...	...		...	...
Ditto	4	...	215	2·92	...	...
Ditto screwed into model	4·4	...	208	2·83	0 2·77	1 : 1·02
No. 2. Flat wick, in lamp	8·5	...	409	...	...	...
Ditto screwed into model	11	3·66	426·6	5·8	0 6·91	1 : 0·84
Ditto second experiment	11·2	3·73	448·5	6·09	0 7·05	1 : 0·86
No. 3. Flat wick, in lamp	10·1	...	528	...	...	...
Ditto screwed into model	15·26	5·08	598	7·8	0 9·6	1 : 0·812
Ditto second experiment	16	5·33	748	10·16	0 10·07	1 : 1·009
No. 4. Flat wick, in stand lamp of Bohemian glass	17·27	...	...	...	...	...
Ditto bnrner screwed into model	20·06	...	...	...	...	...
Ditto second experiment	21·1	7·0	822	11·17	1 2·3	1 : 0·841

2. A pure and white light, superior in brilliancy to any light now in use.

3. Great steadiness of flame, which will cause them to become a boon to many engaged in the various manufacturing branches requiring a steady light. I believe them well adapted for counting-houses, type-setting rooms, &c.

4. Perfect safety from risks of explosion, as no air can possibly mix with the vapour of petroleum before it issues from the wick case. I may mention that I had the inspectors of the principal insurance offices at my place of business in Wood-street to investigate the matter, and that they endorsed my insurance policies most readily, declaring the proposed conveyance of petroleum as safe as that of gas.

5. Great adaptibility for all purposes of illumination where gas is now employed in private houses, public buildings, factories, railway stations, signal lights, and street lights.

6. Saving in cost of 500 to 600 per cent. upon colza oil, and 40 to 50 per cent. upon that of common coal gas, reckoned at 3s. 9d.

From all these considerations, I am inclined to think that the new light will be especially adapted for country districts where no gas can be had, and to places where gas is much dearer than in London. The supply of mineral oils may be said to be plentiful, and a new source of illumination is, therefore, provided, which will become a formidable rival to coal gas.

I am painfully aware, gentlemen, that I have scarcely done justice to the all-important subject of burning mineral oils—the liquid gas which nature has provided for us. To-morrow, some of our most eminent men of science will be engaged in investigating the nature of the universal source of light—the sun—with all the appliances of modern science. Now, when we come to think how little we know about this great source of light and heat, you will forbear with me if I have but imperfectly brought before you the nature of the artificial light, the light which mineral and other oils are capable of producing when properly burned.

NEW PAPER-MAKING MATERIALS, AND THE PROGRESS OF THE PAPER MANUFACTURE.

By P. L. Simmonds, Esq.

The subject which I bring before the society this evening is one of much importance, in which we are all, more or less, deeply interested. There can be no question of the great value of paper as a means of diffusing knowledge, awakening thought, calling forth invention, and civilising the world. It is the handmaid of all arts, of all sciences, and of all trades. Both in an educational and a commercial point of view, an extensive supply of paper, at moderate prices, is of national interest. The laws of supply and demand will, indeed, regulate the question, but discussion and circulation of opinions may result in extended benefit to the paper-maker as well as to the reading and writing public.

The technical question of what is paper, what are the materials of which it is composed, may well be raised, for it led to a trial, some years ago, between the Excise and a paper-making firm, the Attorney-General v. Barry. In the edition of "Johnson's Dictionary" published about the middle of the eighteenth century (1755), paper is defined as "a substance on which men write and print, made by macerating linen rags in water, and then spreading them in thin sheets." "Webster's Dictionary," of our own day, enlarges the list of materials, and describes it as "a substance in the form of thin sheets, or leaves, intended to be written or printed on, to be used in wrapping, &c., and made of a pulp obtained from rags, from straw, from bark, or like materials, pressed and dried."

An historical fact which was brought before this society twenty years ago, by Dr. Crace Calvert, may be again noticed here. It is that paper, made from the papyrus plant, had lasted from 1,822 years before the Christian era to the eighth century. Egypt was invaded by the Arabians and her trade destroyed. It was then for the first time, that cotton paper was first imported from China by the Arabians, who, two or three centuries afterwards, supplied us through Turkey. The manufacture of their flax paper was so successful that cotton paper was completely laid aside until the commencement of the present century, when once more it expelled from the market the linen paper.

Our word "book" is said to have come from the Gothic word for the birch-tree, some part of which, probably the liber, or inner white rind between the bark and the wood, may have been the most convenient substance which nature has furnished in the northern parts of Europe for portable documents. Other substances than of vegetable origin may be written or printed on, of which we have familiar instances in the present day, in our slates and stone tablets, copper and steel plates, parchment and vellum, gelatine paper, silkplay-bills. In olden times, characters, too, were engraven on stone, or impressed in clay, dried and hardened, as the Babylonian bricks, boards of wood covered with wax, plates of ivory and metal, and the leaves of palms were used. The Chinese, Japanese, and Indian papers are made without rags, consisting chiefly of bamboo, the paper mulberry, and other macerated barks and fibres, and their celebrated rice paper, so long a mystery, is now known to be made from the cellular pith of the *Aralia papyrifera*.

Among the influencing causes for the greatly increased demand for paper are the removal of the excise duty on manufactured paper and the stamp from newspapers, the extended number of daily and other journals issued at a cheap price, and the large editions of these called for, owing to the eagerness to obtain intelligence of the progress of the unfortunate war now raging. The increasing commerce of the country must not be lost sight of, and the extensive home and foreign correspondence resulting therefrom, some 700,000,000 letters passing annually through the post. Educational progress also leads to more writing, reading, and book-printing. We have also to remember how many other uses paper sub-serves, as wrapping material, for cardboard, *papier maché, carton pierre*, &c.

Building paper now forms a regular article of commerce in the United States, and more than one public company is doing a large business in it. It is used on the outside of frame buildings, and under shingles and floors, to keep out the cold, and on the inside instead of plastering. It is said to be both warm and cheap. Paper tiles are also used in Saxony for roofing sheds, stables, and barns; and paper collars and other articles of dress have long been in use.

When we consider that 550,000 tons of cotton, 125,000 tons of jute, and 130,000 tons of flax and hemp, were imported and worked up in 1869, besides 53,000 tons of home-grown flax, one would suppose there ought to be a great deal of the waste of these fibres available for the paper-maker. But among the minor tendencies of industries few are more noteworthy than that shown in the increased utilisation of waste materials. As competition becomes sharper, manufacturers have to look more closely to those items which may make the slight difference between profit and loss, and convert useless products into those possessed of commercial value.

Our manufacturers have not been slow to appreciate this truth, as is shown in more than one branch of trade. Thus, the refuse blowings and droppings from the spindles and looms of cotton-mills, which were formerly available for the paper-maker, are now found to possess a high textile value, and form the basis of a distinct branch of trade. Millions of pounds of this waste cotton are now used annually in the fabrication of wadding, common carpets, twine, &c. There are a hundred opportunities among the staple industries of the country to secure an equal economy and profit, by turning to proper uses substances now disregarded and thrown away as waste.

In the manufacture of paper, as well as in all other mechanical industries, there has been great progress made, even in the last half-century. Chemistry and mechanics have each contributed their part. The former has afforded us improved methods for washing, bleaching, and colouring the paper stock, which must yield a different product from what was made by the ancients. The mechanical improvements, too, have been many, both for boiling and running out the pulp. The use of ultramarine, which was at one time almost as valuable as gold-dust, has been so extended and cheapened by the labours of the chemist, that its artificial manufacture must be regarded as one of the triumphs of modern science.

Chemistry has also taught us that the cellulose of all plants is the same as that contained in rags, and that, in fact, the fibre of some plants will give us a paper that cannot be made from rags. Not all plants, however, are adapted to the making of paper. Much depends upon the bark, membrane, and fibre, and there is a difference in the purity of the cellulose in various plants. Chemical tests also show a modification in the fibre of plants. The cellulose of cotton yields a blue colour immediately, with tincture of iodine; that of flax does not turn blue until an acid has been added, and hemp requires both acid and considerable time before the blue colour makes its appearance. These reactions point to the presence and absence of starch and glucose in different species of plants.

The removal of the excise duty on paper, which took effect in the year 1861, renders it difficult to ascertain with any precision the quantity of paper now made in the kingdom, but we may form a fair estimate by looking at the progress under the duty rate, and judge of the advance from the incentives and stimulus to increased production. The following are official figures of the quantity of paper charged with duty:—

	lbs.
1842	96,693,399
1852	154,469,211
1861	229,502,864

From which we may fairly estimate the present production at 300,000,000 lbs.

Our shipments of paper scarcely keep pace with the increased produc-

tion and home consumption, which may be attributed to foreign competition, and the colonial paper mills now established in Canada and Australia. The exports are officially given as follows of British paper :—

	Quantity cwt.	Value £
1860	112,514	450,589
1865	141,075	447,741
1869	214,416	591,436

The exports and consumption compare as follows, in pounds weight :—

	Exports	Consumption
1849	5,966,319	126,166,341
1859	20,142,352	187,684,847
1869	24,014,592	276,000,000 (estimated).

In 1869, our export of paper of different kinds, including paper-hangings, was valued at £727,071. The quantity of foreign-made paper received has been annually increasing of late years. In 1869, 412,900 cwts. were imported, valued at £690,547, of which 49,920 cwts. were re-exported. The following are the imports of foreign-made paper of all kinds in the last three years, in cwts :—

	1867.	1868.	1869.
Printing or writing	174,429	177,220	169,275
Other kinds	151,925	193,387	243,626
Paper-hangings	7,753	5,660	4,435
Total	334,107	376,267	417,306

Besides these foreign figures, we have to consider the quantity used for paper-hangings. The home consumption under this head I can form no estimate of, but give the exports. In 1858, these were stated at 15,000,000 yards, valued at £74,649 ; in 1869, the official returns gave the quantity of paper-hangings exported at 46,617 cwt., of the value of £132,635.

The paper-makers' licences, granted during the time of the duty, afford some idea of the briskness of trade, and the paper-mills at work. I find the number of mills rose from 408, in 1785, to 800, in 1829, (the highest number reached). They then declined annually until 1852, when there were 400, at which, with variations of some 8 or 10, the number has since stood. The licences granted in 1869 were 326 in England, 60 in Scotland, and 22 in Ireland, but all the mills were not at work, and within the last year there have been still further reductions in the number. The "Paper-mills Directory" for 1871 gives the number of paper-mills in working order in England, in 1870, at 274, besides 12 mills not working, making a total of 286, against 290 in 1869, In Scotland there were 63 mills at work last year, against 58 in 1869. The larger number of paper-mills make brown, cartridge, and such like papers ; in England, not more than 100 make printing, news, &c.

If we look at a few of the latest figures regarding the publishing and printing trades, we shall see how important is the question of paper to supply the demand. There are at the present time more than 1,400 newspapers in the United Kingdom, of which 110 are daily, of these 61 are published at one penny, and 34 at one half-penny each. The magazines and reviews number 626. The quantity of paper which these require it is impossible to calculate ; but when we find that one London daily paper asserts its average daily circulation to be upwards of 190,000 copies, and if we assume the other London dailies to have each but half this circulation, we can form an idea of the enormous demand for paper, even in the metropolis. Besides the political journals, some of the literary, religious, sporting, and other publications have very large circulations. But we have also to take books into consideration. According to the "Publishers' Circular," last year there were 4,656 new books and new editions published in Great Britain. In the United States about half this number are issued, and in Germany three times as many. This is independent of the large number of newspapers and books issued in various other parts of the globe. The make and consumption of paper in the United States are nearly as large as our own.

In 1869, we exported 59,291 cwt. of books and imported 11,463 cwt., and the progress in ten years is shown by the figures of 1859, which were 33,915 cwt. exported, and 6,520 imported.

The price of rags mainly regulates the price of paper, for these are the mainstay of the paper maker, although now supplemented to a small extent by crude vegetable fibres. The comparative scarcity of rags and kindred substances has rendered their supply, as a main article for paper-making, more and more inadequate, while the importation of esparto fibre from the Mediterranean countries has likewise failed to meet the augmented demand.

The import of foreign rags suitable for paper-making has increased in the last ten years about 50 per cent. For twenty years it averaged about 10,000 tons, In 1858, it was 11,379 tons, value £246,133 ; in 1869, it was 17,000 tons, value about £300,000. The aggregate quantity of rags annually collected in the kingdom, with those imported, may be taken at 70,000 tons weight, worth at least £1,500,000. It takes 100 tons of rags to make 70 tons of paper. Notwithstanding the rags produced by our population of 30,500,000 inhabitants, added to the large quantity of jute, bagging, linen and cotton wrappers, old sails, cordage, &c., it will be seen that we are largely dependent on foreign supplies of waste materials for our paper-mills. Linen rags have declined in price from £22 18s. per ton, in 1866, to £19 12s., in 1869, and cotton rags from £13 19s. to £12 4s.

The average value of the rags and other paper-making materials imported in the last two years, was about £110,000. The quantities are shown in the following return, in tons :—

	1867.	1868.	1869.
Linen and cotton rags	18,407	17,860	16,980
Esparto	54,512	95,828	86,334
Other vegetable fibres	562	52	1,084
Other materials for making paper	794	615	1,702
Tons	74,275	114,355	106,100

Since the discovery of a method of separating ink from printed paper, old newspapers and old books have entered largely into the paper-makers' material. And the lesson of economy should be learnt, to save for market the waste paper, instead of kindling fires with it and casting it to the winds. Let frugal housewives take a hint, and add the present wasted hundredweights of old paper to the great civilising agent of the present day.

A correspondent of mine well observes :—"For many years it has been pointed out, in every possible way, that an endless variety of cheap materials exists in British tropical dependencies, admirably suited for paper-making, but the ever-recurring difficulty is, not where to get it, nor even what to get, but how to induce any one to bring it, or, if brought, how to induce any one to be the first to use it. This want of spirit is the dead weight which presses so heavily on the paper-manufacturer."

Owing to the increased demand, and the enhanced price of rags, it has been found necessary to employ other substances for mixing, such as, for instance, straw, esparto grass, and wood. Generally speaking and especially as regards the grasses, these auxiliary pulps, however, do not fall very far short in price of the rag-product, and thus, while by such admixtures the immediate demands are met, the cost of paper remains high, and acts as a check on that expansion of the paper-manufacture which is one of the greatest and most urgent requirements of the times.

Wood pulp, chemically produced, although undoubtedly good as to quality, labours under the disadvantage of being too dear, but its production by mechanical agency, which is much less costly, may now be considered as brought to great perfection by means of improved machinery, amongst which Voelter's system claims an undoubted superiority, at any rate, in localities where the raw material is abundant enough to afford supplies for their great converting capacity, and its action is facilitated by a sufficiency of water-power. Under such conditions, each one of M. Voelter's engines of the ordinary size is capable of producing 17 cwt. of pulp daily, at a cost varying in proportion to the nature of the motive power employed, the price of the raw material, the facilities of transport, the rate of wages, and other contingencies.

In all these respects, Sweden, according to a detailed report of Mr. Gustaf Josephson, offers peculiar advantages. The supply of soft pine wood, perhaps the most suitable of all for the manufacture of paper-pulp, and pasteboard, is there practically unlimited, and obtainable at a price of 1½d. to 2d. per cubic foot, whereas in Germany, where a number of such works have been in existence for some time, and have supplied English markets with their produce, which is, however, mostly of

inferior quality, the same material is worth about 3d. per cubic foot on an average. Aspen wood is likewise plentiful and cheap in Sweden.

There are now about 160 of these wood-pulp machines at work on the Continent. Some of those in Germany and Belgium, and about 30 of those situated in the Scandinavian countries, where material is abundant, send their pulp to England as a paper material.

The first mode of preparing wood pulp from the pine and other white woods, was to reduce it into thin shavings, which were soaked in water for six or eight days, and then dried and ground into powder by a corn or crushing mill. This powder was mixed with rags, so as to make a pulp, and the ordinary operation of paper-making was then proceeded with. The principal defect of this material was the shortness of fibre.

The preparation of wood pulp has not hitherto been sufficiently successful to make it rival rags, esparto, or straw. Further experiments may, however, go far to remove the present defects.

Esparto, as it is called in Spain, and alfa on the African coast, is a coarse, rushy grass, which has long been used as a fibrous material for rough yarn and cordage, and more than thirty years ago was recommended as a paper-making material, but was only brought into extensive use about sixteen years ago, by the persevering efforts of Mr. Thomas Routledge. No material alteration in the machinery or apparatus is required for working esparto, and much less power is necessary. According to a practical authority,* the successful working of this fibre depends mainly on the careful and proper adjustment and strength of the chemicals employed. The quantity of soda-ash required for neutralising the gummo-resinous matters in the fibre, so as to admit of its being made into pulp, is very large, though not so great as is required for straw; and the fibre, unlike rags, never having before been subjected to bleaching or other chemical treatment, also requires very much more bleaching powder to bring it to colour suitable for printing paper, The quantities required are from five to six times as much as for cleansing and bleaching the coarsest rags.

In a late circular of Messrs. N. W. Chittenden and Co., fibre brokers, they state that, "during the past year, numerous small importations of various descriptions of fibre have occasionally been made, and ready experiments have been afforded to test their capabilities, yet none has been found as a practical substitute; and during the past twelve months upwards of 93,750 tons of esparto have been imported into the United Kingdom, and although there has been but little falling off in the importations of other material previously used, the price of esparto still keeps at about £10 per ton. What effect this may have upon manufacturers who have been at a heavy expense in erecting machinery to work this article, when it was supposed that any quantity could be had at £6 or thereabouts, with but slight fluctuations in value likely to occur, we cannot say, but it seems an astonishing fact, that although the consumption of paper has been greater than ever, and that most raw materials from which it is produced have risen, our makers have not combined to raise the price of their production in proportion."

A correspondent, reading the discussion which took place last year, in the *Standard*, on paper materials, sent me specimens of pulp which he had prepared in Jamaica, under difficulties, from various substances, such as the bamboo, different fibrous plants, simply crushed and macerated, and wood pulp from trees of large growth. The fibrous plants of Jamaica, he observes, are numerous, and deserve a greater amount of attention, but hitherto nothing of a substantial or permanent character has been done practically. The Jamaica papers have since taken up the subject. A recent *Kingston Morning Journal* has the following editorial remarks:—"It seems, from all we can gather, that there is a market for our fibres, and such material as they convert into pulp, if only we would set to work to produce them. There is no lack of material for this purpose. From one end of the island to the other it abounds, of various kinds, and of various qualities. It is really pitiful to ride about the country, and see the acres of penguin that uprear their heads and spread themselves about as they can find space, preventing all other vegetation from thriving, while it is itself practically of no use whatever, and may be regarded as an encumbrance of the ground. What a mine of wealth we have in these same penguin plants, if only people would take the trouble to set about to extract it. Years ago, the matter was talked over, and it was then set forth that the fibre is abundant, is strong, is of excellent quality for manufacture into certain kinds of cloth and cordage, while the material is as 'common as dirt' in the country. It is a pity that so little—indeed, nothing beyond the trying of a few experiments—has ever been done to turn it into practical and useful account. Besides the penguin for the production of fibre, there are the plantain and the banana plants. There is not a peasant or small settler who does not cultivate them pretty extensively. Travelling through the mountain districts, the very first things to apprise the belated traveller that he is getting within the circle of humanity, is not so much 'the watch-dog's honest bark, baying deep-mouthed welcome,' or unwelcome, as the sight of those graceful plants, waving their leafy wings in the soft night air that plays around them; and, when the village is reached, there is not a cottage but is surrounded by them; there is not a garden in which they do not abound. Then there are the fields, or 'grounds,' that lie beyond the confines of home, on the higher lands, in which plantain and banana plants are to be seen also growing abundantly. These require little or no cultivation. They propagate themselves by means of the suckers that shoot out of their roots, and, except occasionally pulling the grass from around those roots, the trouble they occasion the husbandman is of an infinitesimal character. The plants abound in fibre of a coarse character, that would be valuable in the manufacture of cordage, while the pulp might be converted into paper of a coarse description. All the use that is made of the plant at present is to cultivate it simple for the sake of its fruit. The other portions of it are thrown down, and lie on the ground and rot. There is some singular fatality attending this country, that so much that is useful, so much that is really valuable, is allowed to grow up and then to rot, when it might so easily be converted into money."

The paper-yielding stems of the plantain and other indigenous plants have been too long neglected. Useful and tough kinds of paper have been made from them. Simple pressure between rollers and washing would appear to be sufficient for the separation of the fibres of most of them.

A Jamaica correspondent sent me by the last mail a copy of a daily paper, which reports that the governor, "Sir John Peter Grant, is turning his attention to the development of the fibrous wealth lying latent and running to waste in this island. In plainer language, his Excellency thinks there is money to be made by preparing for market the numerous varieties of plants growing without cultivation all over the country, from which fibrous materials may be extracted, for the manufacture of cordage, textile fabrics, and paper; and we learn that he is about to bring to this country a person experienced in the extraction of fibres from the plants containing them, if not for the further conversion of the materials so evolved into manufactured articles. At present, we do not go so far as to insist on the manufacturing part of the project, but we would content ourselves just now with an impetus, such as it is said Sir John contemplates, to the growth and preparation of the raw material for the purposes of the manufacturers of Manchester, Glasgow, and other towns and places in the United Kingdom. We are not so ambitious as to 'despise the day of small things.' Therefore, for the present, at least, we should be quite satisfied to witness the shipment of a few tons of raw material spoken of, by way of a beginning to a new industry which, we are convinced, if followed up with spirit, is calculated to provide a handsome living, if it do not lead to affluence, to such persons as may engage therein, provided that they set about the work understandingly, and carry it on skilfully, and at the lowest possible cost. Nor does it appear to us that any very elaborate process, involving complicated and costly machinery, is absolutely necessary for the purpose of separating from fibre-producing plants, such as we have in such luxuriant abundance in the island, the ligaments, which form their strength and real substance, from the feculences which keep them together in a state of cohesion. Now, the Jerusalem dagger, as well as the common dagger (this I believe to be *Yucco gloriosa* and *Aloefolia*), grow luxuriantly all over the island. In regard to the latter, it is too common to render necessary one word about it. The other variety is not so well known. The leaf is more soft and pliable, and seems to us to be more adapted to the manufacture of cordage, and perhaps for textile fabrics, than the better-known kind. We can assure our readers, and we now address ourselves more particularly to those abroad, who are in any respect interested in spinning and weaving—that the fibre of the two plants we have already named require no bleaching—at least it seems so to us; for immediately as it is cleaned, washed and dried, it is as white as the best bleached linen thread, and much whiter than the printing paper on which this article has been written. Nor this alone. It is as fine as the finest silk as it comes from the worm, tough, and elastic. Unlike the plantain fibre, which breaks if made into a knot, it is tenacious, and can bear any complication of knots without snapping. This is one of the greatest desiderata in all fibres, whether for cordage or textile purposes. Then, if we mistake not, whatever substance is suitable for cordage and woven fabrics is equally suitable for manufacture into paper, with this advantage, that, for the latter purpose, the waste and refuse, embracing short, broken fibres, may be used with equal benefit to the long, sound fibre employed for the other purposes named. And as there has for many years existed an outcry about the scarcity of rags, which the wars now raging will serve to enhance, from the demand for lint and bandages for the wounded, it seems to us that we have hit upon a plan—which, by the way, we did as long ago as the time of the Crimean war—whereby the wounded may be benefited,

* Mr. W. H. Richardson, on the Paper Manufactures of Northumberland and Durham.

without in the least inconveniencing the paper-manufacturer. We may add to this, that this latter will be able to turn out a superior article, because he will have for a stock a raw material much stronger than the old rags he has been in the habit of employing in his manufactory. We have already alluded to the marked whiteness of the fibre of the dagger. In this, as well as in its greater flexibility and tenacity, it is far superior to the fibre of the plantain or banana of any description, which would require considerable bleaching for either paper or any of the texile fabrics."

The bamboo is not a new paper material, although it has only recently been introduced into this country for that purpose. Mnch of the common Chinese paper is made from it, as may be seen described in Herring's work on Paper, page 31. The American paper-makers have for some time drawn supplies from British Guiana, Jamaica, and other parts of the West Indies. In the paper which I read before the Society two years ago,* I called attention to what the Americans were doing with bamboo as a paper material, and this seems to have drawn attention here to this gigantic grass.

During last year, some supplies of a very excellent new material were imported from the Portuguese settlements on the west coast of Africa, where considerable quantities may, it is said, be obtained. It is the fibrous bark of a Sterculiaceous tree, the baobab *(Adamsonia digitata)*, and, from its tough fibrous net-work, it would in quantity be very valuable to the paper-makers. It is not a tall tree, but attains gigantic dimensions in growth, being described by travellers as a "vegetable monster," and "behemoth of the forest," being frequently 80 or 90ft. in circumference. Livingstone asserts that nothing short of boiling the tree in sea-water could possibly destroy its power of vitality. Constantly barked by the natives, the tree nevertheless retains its full vigour, and a removal of the very core or centre of the stem wonld not, according to that traveller, affect the existence of the tree; and "the reason is," to quote his own words, "that each of the laminæ possesses its own independent vitality; in fact, the baobab is rather a gigantic bulb run up to seed than a tree." This tree or an allied species *(Adamsonia Gregorii)* is found in the West Indies and North-Western Australia. The bark fetches readily here £14 to £15 per ton. This bark furnishes indestructible cordage, and a close thread used for cloth and ropes. Ropes made from it are said to be so strong that there is, in Bengal, a saying, "as secure as an elephant bound with baobab rope."

At a late meeting of the Scottish Paper-makers' Association, the chairman urged that the attention of makers should be turned to the introduction of other materials to cheapen the cost of production, or to increase the per centage of paper yielded by the materials now in use. Wood-pulp might soon be more generally used, as, from recent information, there were means lately discovered, and soon to be patented, whereby the fitness of this material would be greatly improved, and its price be exceedingly moderate. An inquiry into the practicability of growing a vegetable fibre at home as a substitnte for esparto was held by several Scotch paper-makers with the Chamber of Agriculture, but no definite conclusion was arrived at. The general opinion, however, was, that straw was the cheapest and best material that could be had, but great difficulty exists in obtaining large supplies, owing to the lease stipulations requiring it to be consumed on the farm. The market price of straw here being also £6 per ton above what it is in Sweden and Belgium, it can be imported from those countries cheaper than it can be bought here.

The vacoua sugar bags, which are made from the tongh longitudinal fibres of the leaves of the *Pandanus utilis* and other species of the screw pine, are a useful paper material. Three millions of these bags are made annually in Bourbon, and a large number also in Mauritius. The leaves are cut every second year, and each plant yields enough for two large sacks or bags. The leaves yield paper of good quality, light and strong.

In Australia, attention is being directed to the utilisation of local materials for their paper-mills. At the recent Intercolonial Exhibition at Sydney, in September last, a bronze medal was awarded to the Paper Company for its brown, printing, and news-printing, made at their Liverpool mill. The brown paper was chiefly made from refuse New Zealand flax; the printing is used by the local journals. The hand-made papers, shown by Dr. Mueller, of Melbourne, proved from what a great variety of vegetable fibres paper can be made, but the difficulty to be conquered is commercial—not mechanical—the cost of reducing much of the fibre into paper being prohibitory.

A select committee of the House of Assembly of South Australia reported, in August last, that thousands of tons of material, equal to any demand, and suitable to the manufacture of fibre, is growing extensively in various parts of the colony, and a large proportion on the Crown lands, while the cutting of it does not destroy the plant, but tends to improve it. The committee report their opinion that a new and valuable industry might be opened up, not only to supply the colony with material useful for various manufactures, such as hemp, rope, and paper, but there would also arise a very large European trade. The committe therefore, recommend that a bonus of £2,000 be offered by the Government for the first 500 tons produced in the colony.

Dr. Mueller, in an elaborate article on the barks, foliage, grasses, rushes, &c., of Australia suited for paper-making,* remarks that forest regions and coast lines, swamps and flats subject to inundations, should prominently yield the material for the factory; for, on open pastures or otherwise occupied tracts of country, even paper material cannot be harvested for an unlimited period, at the expense of the soil, with impunity. In factories situated in the vicinity of forests, the soda expended in paper manufactures might be profitably regained by evaporation of the ley, and crystallising it with coal or sawdust. In viewing (he adds) the immense supply of various kinds of paper material here cheaply available, there is no reason why they should not form, closely pressed, an article of export probably less inflammable than rags; and, still more, it may safely be anticipated that, together with the consumption of rags in local factories the new articles indicated will largely enter into the fabrication of paper, the product of Victorian industry.

I have not thought it necessary to take up the time of the meeting by an enumeration of all the Australian materials on which Dr. Mueller has experimentalised, with more or less success. Many of these have been repeatedly brought under notice, others are new; but I have specimens of various papers made from them here, for the inspection of those interested. These papers have not been subjected to chlorine, or drawn through size.

In the reports of the jurors at the New Zealand Exhibition of 1865, it is stated that New Zealand produces a number of fibrous plants and grasses suitable for the manufacture of paper, a branch of industry which must, at some future time, become an important one. The bountiful supply of pure water with which almost every portion of the colony is blessed, and the facilities which exist for the erection of mills to be driven by water power, combined with the abundance of paper-making material, which grows in profusion throughout the colony, constitute New Zealand as *par excellence* a favourable country for the production of paper for the supply of this and the other Australian colonies. With regard to paper-making material, the *Phormium tenax* must again occupy the first place.

Not only is the fibre admirably suited to that purpose, but it is the more valuable, inasmuch as the refuse particles of fibre, after its preparation for spinning, are available for the manufacture of paper. In the event of the cultivation of the *Phormium tenax*, there will always be a large quantity of damaged, and what would otherwise be waste leaves, which would be valuable to the paper-maker. Forty years ago, paper was made of it to print an edition of a work by Mr. John Murray, of Edinburgh, on the plant and its uses. The peculiarity of this paper is its tenacity, which property should make it valuble for documents and printings to stand a great deal of wear and tear. No better paper could be used for bank-notes, or for the printing of valuable standard works.

Many of the native grasses of New Zealand are sufficiently fibrous for the manufacture of paper, and the profusion in which they grow on almost every variety of soil, and under every condition of the climate, is an additional reason why efforts should be made to utilise them. One variety of grass in particular claims attention, from its resemblance in many important features to esparto; this is the "snow grass," of the tussocky grasses of the colonists (*Schoenus pauciflorus*, Hooker), which grows rank and luxuriant at high elevations and on barren soil, in the interior of the Middle Island. Experiments have been made at Dunedin as to the paper-making qualities of this grass, and the trial was sufficiently satisfactory to establish its value for the purpose. But while I direct attention to these paper-making materials, I fear Australia is too far distant to be thought of for any extensive supply of raw material, and we must look to nearer quarters, such as the shores of Northern and Western Africa, Brazil, Central America, and the West India Islands.

Seven or eight years ago, in a work which I published on the utilisation of waste substances, I suggested that the woolly fibre adhering to the hulls of the cotton seed might be economised in the manufacture of paper, and I am glad to find that this, like very many other hints thrown out, has since been carried into practice.

At the last meeting of the British Association a paper was read by Mr. Thomas Rose, of the firm of Rose and Gibson, of Sankey Mills, Earlstown, on the further utilisation of cotton seed, and especially by converting the short cotton fibres adhering to the husk of the herbaceons

* *Journal*, vol. xvii., 1869, p. 175.

* "Journal of Applied Science," August, 1870.

cotton, and the husk itself, into paper. The seed yields, in round numbers, 50 per cent. of kernel and 50 per cent. of fibrous husk. The kernel yields about one-third crude oil and two-thirds cake. The fibrous husk gives an average of 30 per cent. pure fibre. The process of operating is this, the cotton seed is fed between a pair of rollers, running at differential speed, and not quite in contact. This cracks the husk or shell, and allows the solid kernel to fall out and be easily separated. A system of riddling further separates a great deal of the dry, broken husk. After this it is boiled in caustic soda, in a revolving boiler, by which means much of the remaining husk is got rid of, and final washing so completely liberate the cotton that it is ready for bleaching. After this process, it is reduced to pulp, and converted into paper. Supposing this to prove a success commercially, of which Mr. Rose (who is now in America on the subject), appears to be sanguine, it will further utilise a waste product on which I have often spoken in former years in this room, and add something to the wants of the paper-maker as regards raw material.

In a late number of the "New Orleans Picayune (Nov. 10, 1870), I find an article giving elaborate statistical calculations about the value of the cotton seed and its subsidiary products; but I am a little sceptical as to American estimates and figures, particularly when the money value of the oil, oil-cake, and ashes of the hulls, as a fertiliser, are set down at the large sum of £11,000,000 sterling, or equal to one-fourth of the value of the incoming crop of cotton. The quantity of cotton seed from an American crop of three million bales is represented to be 2,250,000 tons. Now, sharp as our American cousins are in turning matters into money, they do not appear yet to have thought of utilising the fibre. If this is all woolly seeded cotton, the weight of seed spoken of ought to yield about 300,000 tons of pure fibre, worth, to paper-makers, not less than £7,500,000. And this is quite irrespective of the bark of the stem of the cotton-plant, which I have not yet heard is economically used.

Looking at the utilisation of this small cotton seed fibre, I see no reason why another material should not be available, in the fibrous husk or covering of the betel nut of India (*Areca catechu*), which is in such general use throughout the east. The fibre has a soft and cotton-like feel, and is capable of being spun into twine. Immense quantities of these husks are now thrown away, and, as a paper material, they ought to be collected in large quantities and at little cost. From Ceylon, about 70,000 cwt. of these nuts are shipped annually, and large quantites from Penang, Sumatra, and Travancore, and from other quarters there are also large exports.

One material has been again brought into notice, the New Zealand flax lily (*Phormium tenax*). Twenty-five years ago, it was shipped from the colony as a paper material in solid lumps, to lessen freight. The paper obtained from it is the strongest of all. The subject, from that time to the present day, has been one of almost constant discussion. The readiness with which the large richly-fibrous leaves can be turned into pulp for a very substantial paper, entitles the plant not alone to consideration, but also the fact that it may be permanently established with the greatest ease in any swampy ground.

The leaves of many palms, but chiefly of the dwarf palm, *Chamærops humilis, Phœnix spinosa*, and other species, have lately been imported for paper-making, and are found useful if well separated from the leaf-stalk, which is hard, stiff, and brittle.

A patent has lately been taken out for applying the creeping stem of the antidote cocoon (*Feuillœa cordifolia*) as a paper material. This is a cucurbitaceous perennial scandent plant, climbing on the highest trees, very common in Jamaica.

It has been well remarked that it is from a careful observation of the laws of vegetable growth and decay that man has been enabled to take advantage of many of the beautiful vegetable products that lie scattered about in luxuriant profusion, and in proportion to the pains he takes to observe the laws of nature, and the judgment he displays in applying this knowledge to scientific or useful purposes, so are the results beneficial to the community at large. One man looks perhaps at the chemistry of vegetables, another merely at the physiology, while a third considers it useless to waste time with such abstruse studies, and inquires merely what is the mercantile value of fibrous substances, and how cheaply they can be brought into the market. Now, all these inquiries have their relative importance.

In this superficial inquiry on paper-making materials, I have merely touched upon a few of the more prominent, without going into practical details, which can best be supplemented by those present who are specially engaged in the manufacture. The subject will not have been introduced in vain if any of the facts or suggestions I have brought forward shall result in benefit to those who are more specially interested in paper-making.

MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this association was held on Tuesday, January 10th, 1871, Sir William Fairbairn, Bart., C.E., F.R.S., LL.D., &c., President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, which on that occasion was for two months, as at the previous meeting the attention of the committee was occupied with other important business. The following is an abstract:—

"During the past two months 312 visits of inspection have been made, and 740 boilers examined, 494 externally, 7 internally, 17 in the flues, and 222 entirely, while in addition 9 boilers have been tested by hydraulic pressure. Three of these hydraulic tests were ordinary ones, simply to ascertain the sufficiency of boilers already in work, while in the other 6 cases the boilers were new ones, and were tested by hydraulic pressure, as well as specially examined, both as regards their construction and complement of fittings, before leaving the maker's yard. In the 740 boilers examined, 105 defects were discovered, 4 of them being dangerous. Furnaces out of shape, 4; fractures, 18—2 dangerous; blistered plates, 9; internal corrosion, 32; external ditto, 9—1 dangerous; internal grooving, 11—1 dangerous; external ditto, 2; feed apparatus out of order, 1; water gauges ditto, 2; blow-out apparatus ditto, 1; pressure gauges ditto, 12; boilers without feed-back pressure valves, 4.

"EXPLOSIONS.

"On the present occasion I have ten explosions to report, by which six persons have been killed and fifteen others injured. In most of these cases the scene of the catastrophe has been visited by the Association's officers, and full particulars obtained. These will be found reported below. Not one of these explosions sprung from boilers enrolled under this Association.

"Before entering on the details of the explosions just referred to, a few additional matters of interest that have arisen in connection with No. 36 Explosion since it was reported on a previous occasion, may receive a brief notice.

"THE TRIAL OF TWO BOILER OWNERS FOR MANSLAUGHTER.

"No. 36 Explosion.—In the report given last month on this explosion, which occurred in Liverpool on Tuesday, October 4th, killing four persons and injuring four others, it was stated that the owners of the boiler had been committed for manslaughter. Since then they have been tried at the recent Liverpool assizes, and a brief reference to the proceedings at the trial, as well as to its issue, may not be uninteresting.

"The facts of the explosion, as it will be remembered, were briefly as follows:—A little boiler, old, second-hand, and worn out, reduced in places to little more than the thickness of a shilling, worked at a pressure of 60 or 70lb. on the square inch, and set in the midst of a number of dwelling-houses, burst, spreading death and destruction all around, in consequence of which the owners, as already stated, were committed to take their trial at the assizes for manslaughter.

"The case, as it frequently happens at the trial of boiler owners for manslaughter consequent on explosions, broke down in the prosecution. The grounds for this, in this instance, were as follows:—About six months before the explosion the owners, as stated in the last Monthly Report, had directed a fitter in their employ to make an examination of the boiler. In consequence of this he had got inside it, but had not passed through the external brickwork flues to examine the plates externally. Yet he had assured the owners that the boiler was all right, and would last them their lifetime. The judge, without any proof whatever, assumed that the fitter was a competent boiler inspector, and therefore decided that the owners had discharged their duty, had freed themselves from all responsibility, and should be at once acquitted. One of the jury, who was a boiler owner, rose and protested that such an examination as that made by the fitter was worthless, and was in fact no examination at all. But this did not influence the judge's decision. He considered the owners had deputed their responsibility, and thus exonerated themselves. The parents of two of the children who were struck down and killed in their own bedroom by the explosion of this old and worn out boiler, as well as the mother of the lad who was killed in the works, although they did not wish that the owners of the boiler should have been submitted to punishment, yet felt that such a view of the matter as that taken by the judge was eminently unsatisfactory, and it is thought that this dissatisfaction must be shared by all who hope that good may arise from the committal of boiler owners for manslaughter. It is thought that the view of the matter taken by the judge, viz., that a boiler owner may shirk the responsibility of working a bad boiler simply by hiring some incompetent man to inspect it, is most mischievous, and renders the position of all those

living near boilers, more especially in crowded localities, more unsatisfactory than before.

"This explosion and trial are of special interest from the light they throw on the important subject of steam boiler legislation, now before Parliament. It has been recommended by some that Parliament should simply enact that every boiler in the kingdom should be inspected, a registrar being appointed to see that this is done, leaving it optional with the boiler owner to select any one as an inspector he may think fit, and allowing any one to constitute himself a boiler inspector. This explosion shows that such a system would be worse than useless. The boiler in question had been inspected and pronounced sound, but yet burst with the most disastrous consequences six months afterwards. Such a system might lead to the expenditure of about a quarter of a million of money per annum for the purchase of certificates, but it would do nothing to secure their integrity, so that it would lead to an indiscriminate scramble for the money, and an indiscriminate issue of worthless certificates. In fact, inasmuch as a license could be procured on the presentation of a certificate, while certificates could be purchased from any one styling himself an inspector, it would simply amount to a legalisation of bad boilers.

"As the view is somewhat generally entertained that the simple enforcement of inspection would be all that is needed to prevent boiler explosions, it is trusted this reference to the history of the Liverpool explosion and trial will not be thought uninteresting at the present juncture.

"The following is a tabular statement of the steam boiler explosions which have occurred during the past two months :—

'Tabular Statement of Explosions from October 21st, 1870, to December 31st, 1870, inclusive.

Progressive No. for 1870.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
41	Oct. 21	Particulars not yet fully ascertained	1	0	1
42	Oct. 25	Locomotive Internally-fired	1	1	2
43	Oct. 27	Single-flued or 'Cornish' Internally fired	1	0	1
44	Nov. 3	Locomotive Internally-fired	0	1	1
45	Nov. 17	Plain Cylindrical, Egg-ended Externally-fired	1	2	3
46	Nov. 19	Single-flued, or 'Cornish' Fired with waste gas from blast furnaces	0	0	0
47	Nov. 24	Marine Cylindrical, with return flue—Internally fired	1	1	2
48	Dec. 2	Plain Cylindrical, Egg-ended Externally-fired	0	3	3
49	Dec. 16	Balloon, or 'Haystack' Externally-fired	1	5	6
50	Dec. 29	Locomotive Internally-fired	0	2	2
		Total	6	15	21

"The Collapse of a Furnace Tube from Weakness.

"No. 43 Explosion, by which one man was killed, occurred at half-past eleven o'clock on the morning of Thursday, October 27th, at a mine.

"The boiler was of the Cornish class, having one furnace tube, in which the fire was placed, running through it from end to end. The length of the boiler was 36ft., its diameter in the shell 6ft., and in the furnace tube 3ft. 8in.; while the original thickness of the plates was three-eighths of an inch, both in the shell and tube, the load on the safety-valve being at least 50lb.

"The boiler gave way in the furnace tube, which collapsed from one end to the other, and also severed transversely, the crown flattening down, and the bottom rising up till they met together. On the occurrence of these fractures, the shell, with about 10ft. of the furnace tube, was lifted from its seat, and hurled backwards to a distance of about 80 yards, while the front end of the boiler with another part of the furnace tube was thrown in an opposite direction, and one of the attendants killed.

"The cause of the explosion is one of which numerous illustrations have already occurred. The furnace tube, though so long and so large, as well as so thin, was not strengthened, as it should have been, and as all well constructed boilers are, either with flanged seams, encircling hoops, or other suitable appliances for preventing collapse, in consequence of which the furnace tube was not adapted for working at more than half the pressure at which the safety-valves were loaded, so that it collapsed merely from weakness. In addition to the structure of the furnace tube, it may be stated that, although the original thickness of the tube appears to have been $\frac{3}{8}$ of an inch, it was found, after the explosion, to be little more than $\frac{5}{16}$ in some places, or than a $\frac{1}{4}$ of an inch at the point of fracture.

"It may perhaps be pointed out that this was not the first explosion to which this boiler gave rise. The furnace tube had collapsed about five years before, when it was taken out and replaced by an old one, which had to be repaired and lengthened by about 8ft. to make it fit the boiler. It was this renewed furnace tube from which the second explosion, now under consideration, sprung.

"It should perhaps scarcely pass unnoticed that the safety-valve arrangement was by no means satisfactory. The boiler from which the explosion sprung was one of a series of three, each boiler having a single safety-valve, so that there were three in all. They were so loaded, however, that one of them usually did all the work, while at the time of the explosion the boiler fitted with the working safety-valve was laid off, so that the other boilers were left to their own resources. Precise information could not be obtained as to the condition of the safety-valve on the exploded boiler, but it was significantly stated by the engineman that it was 'loaded,' which, on inquiry, appears to have meant that there was a piece of chain, brick, &c., on the lever, in addition to the ordinary weight. No. 2 safety-valve had a quarter of a hundred weight hung on to the end of the lever, in addition to the ordinary ball, which brought the load per square inch up to a little above 50lb. These irregularities, which would have been corrected on a system of competent inspection, very probably hastened the explosion, though the main cause, as already stated, may be taken to be the weakness of the furnace tube.

"At the inquest, no light whatever was thrown upon the cause of the explosion. The day and the night enginemen gave evidence, both having been present when the furnace tube collapsed. The day engineman stated that the boiler had burst five years before, after which it had been thoroughly repaired. Although he had examined the shell and furnace tube of the boiler since the recent explosion, he could not in any way account for it. He was sure there was plenty of water in the boiler, having tried the gauge taps but ten minutes before the explosion. He had no apprehension of danger, otherwise he would not have remained near the boiler. The coroner stated that they were as far off as ever from the cause of the disaster, and suggested an adjournment for other evidence. The jury, however, considered this unnecessary, and proceeded to examine the other engineman. He also stated that there was plenty of water in the boiler at the moment of failure, and that he was sure of this as he had tried the gauge cocks himself. He was quite unable to account for the explosion. He had attended the boiler for twelve years, and excepting when it exploded about five years since, it had always worked well. The jury brought in the usual verdict of 'accidental death,' merely adding that the cause was the bursting of a boiler.

"This explosion and inquest are both suggestive. Here was a boiler bursting clearly from the weakness of the furnace tube. Yet it is stated that the attempt was made, as usual, to attribute the disaster to shortness of water, and thus to exonerate the boiler maker at the expense of the boiler minder. This explosion occurred in a county in which the furnace tubes of boilers are constantly collapsing, whereby life after life is sacrificed, and though so much has been said and written upon the necessity of strengthening furnace tubes either with flanged seams, encircling hoops, or other appropriate means, yet these simple precautionary measures are persistently neglected, while at the inquest consequent on the explosion under consideration the coroner had to state that they were just as far from ascertaining the true cause of the catastrophe as ever, and the jury pronounced the disaster to be 'accidental.' These facts plainly show that nothing will avail for the preven-

tion of explosions but the enforcement of competent inspection by law, and, further, that any system of inspection founded on a local basis will be altogether inadequate for the public safety.

"An Explosion from External Firing.

"No. 45 Explosion, by which one person was killed and two others injured, occurred at a colliery at half-past one o'clock on the afternoon of Thursday, November 17th.

"The boiler was of the ordinary colliery class, being externally-fired, and of plain cylindrical, egg-ended construction. Its length was 26ft. 3in.; its diameter 6ft., and the thickness of the plates barely $\frac{3}{8}$ of an inch, while the load per square inch on the safety-valve was 35lb. The boiler was plated longitudinally, while there were ten plates in the circumference.

"The boiler rent over the fire, at one of the longitudinal seams of rivets situated at about 2ft. 6in. from the central or keel line at the bottom. This primary rent ran along from rivet hole to rivet hole for about 6ft., and then assumed a zig-zag circumferential direction at each end of its course, thereby dividing the shell into three parts.

"This explosion has been attributed to shortness of water, but it was not found that an examination of the parts corroborated this view. Not only were there no signs of overheating either on the inner or outer surfaces of the boiler, but the fractures were sharp and pointed, as if made when the plates were cold, rather than being ragged and woolly as they would have been had they been made when the plates were hot. This explosion, therefore, is attributed to the untrustworthy character of plain cylindrical, externally-fired boilers, of which so many illustrations have been given on previous occasions; while it may be added that the age of this boiler was considerable, being from 30 to 32 years, and that the thickness of the plates at the line of fracture was but $\frac{5}{16}$ of an inch.

"Another Collapse from a Weak Furnace Tube.

"No. 46 Explosion, by which fortunately no one was either killed or injured, occurred at an ironworks, at about half-past six o'clock on the afternoon of Saturday, November 19th.

"The boiler was of the Cornish class, having a single furnace tube running through it, but in addition to being heated by the firegrate placed within the tube, it was also heated by the waste gases passing off from the blast furnaces. The length of the boiler was 43ft., its diameter in the shell 7ft., and in the furnace tube 4ft., while the thickness of the plates was $\frac{7}{16}$ of an inch, and the stated load on the safety-valve 50lb. per square inch, but as there was no steam gauge, the exact pressure was not learnt. The age of the boiler was considerable. It had been working 31 years, but had been repaired from time to time. The boiler was one of a series of eight, all of which it is stated were worked night and day continuously for two months at a time, with the exception of two or three hours on Sunday morning when the engines stood for packing. One boiler was laid off each week in rotation, for cleaning, but as the demand for steam was quite as great as the boilers could meet, there was no spare boiler, and as the stoppage of one of them, even for cleaning, involved a decrease in the product of the blast furnaces, time for repairs was cut down to the lowest possible point.

"The boiler gave way, as in the case of No. 43 Explosion, in the large furnace tube, the crown coming down, and the bottom rising up till in one part they came within 6in. one of the other. The furnace tube and ends of the boiler were thrown to considerable distances, and in all probability would have destroyed many lives had not the explosion occurred at half-past six on Saturday evening, when a number of the workmen had left.

"On turning to the cause of the explosion, it may be explained that not having had the advantage on this occasion of deriving my information from an examination on the spot by an officer of this Association, the weight upon the safety-valves and others details cannot be given so positively as they otherwise would have been, but it may be pointed out that from the fact that, in the collapse of the tube, the bottom had assumed an upward direction, as well as the top a downward one, it would appear that the explosion was not due to shortness of water, but either to weakness of construction or excessive pressure of steam, while a furnace tube 43ft. long and 4ft. in diameter, not strengthened with any encircling hoops or other approved means, may be pronounced as a mechanical barbarism. It is understood that orders had been given to strengthen the furnace tubes in these boilers with hoops of angle iron, but that the order had not been executed, possibly from the want of a spare boiler.

"Regarding, therefore, the proportions of the furnace tube, it is thought that the explosion may be fairly attributed to malconstruction; while attention cannot be too strongly called to the dangerous practice of so over-driving boilers that the cannot be laid off for a sufficient time to afford convenient opportunity for repairs.

"An Explosion from a Badly Constructed Marine Boiler.

"No. 47 Explosion, by which one person was killed and another injured, occurred on board a steam tug while towing a vessel in harbour at six o'clock on the morning of Thursday, November 24th.

"The boiler, which was one of two set side by side, was of horizontal cylindrical construction, the back end being hemispherical and the front flat. It was fired internally, having a single furnace tube connected to a return flue running to the chimney. The outer shell of the boiler was about 12ft. 6in. long, by 6ft. 3in. in diameter, and made of plates $\frac{5}{16}$ths of an inch in thickness. The furnace tube, which was 9ft. long, instead of being circular in cross section, was oval, and measured about 3ft. 10in. in width by 2ft. 10in. in height, while the original thickness of the plates appears to have been $\frac{5}{16}$ths, though reduced in some parts to a $\frac{1}{4}$in., and in others to $\frac{3}{16}$ths of an inch. The pair of boilers was fitted with one safety-valve between them, while the ordinary working pressure is stated to have been about 17lb. on the square inch.

"The boiler gave way in the furnace tube, the crown bulging downwards, till at one part it rested on the fire-bars. In consequence of this bulging, the plates tore away from the angle iron at the furnace mouth, and also rent transversely at the third ring seam of rivets from the front, as well as for a length of about 7 or 8ft. on one side of the furnace crown where the bulging hinged. The result of these rents was that the steam and hot water in the boiler poured out in the firing space and engine-room in a torrent. The boilers, however, were not moved from their seats, and fortunately the fireman had just left the stokehole after satisfying himself as to the sufficiency of the water supply, and thus narrowly escaped. A lad, however, who had gone down to the engine-room for a piece of waste, was caught by the torrent, and dashed across the engine-room, in consequence of which, he was found, as soon as the room could be entered, half an hour afterwards, to be quite dead. The engineman also who, it is understood, was standing on deck, near to the boilers, was severely scalded.

"The particulars already given almost render any explanation of the cause of the explosion unnecessary. It must be apparent that the furnace tube was weak from its flat crowned oval shape, and light plates, while to this it may be added that it had been repaired with a couple of large patches, put on with bolts instead of with rivets. The owners appear to have been so well aware of the defective state of the boiler that a new one was in course of construction, and was to have been ready to replace the old one in a few days after the date of the explosion. It may also be pointed out that the front end of the boiler, being 6ft. in diameter, had a pressure upon it of about thirty tons, yet though quite flat and but $\frac{7}{16}$ths of an inch in thickness, it had only a single diagonal stay to tie it to the shell and prevent its being blown out into the engine-room, as has so frequently been the case in other boilers of similar construction. The plan, also, of having but one safety-valve to two boilers was defective, while it should be added that there were no feed back pressure valves to prevent the water from one boiler being vomited into the other, which is a most serious omission. It will thus be seen that the boilers altogether were thoroughly second-rate, and most deadly companions for any fireman or engineman, especially on board ship, so that without further comment, the explosion may be attributed to the gross malconstruction of the boiler.

"It appears that this was by no means the first occasion on which these boilers had burst. In fact it may be said that they were in the habit of bursting. The furnace crown of the boiler from which the explosion now under consideration sprung, had come down on a previous occasion although not to the same extent, but the furnace crown of the other boiler had given way a few months since in a very similar manner to the collapse from which the fatal consequences, described above, had resulted.

"It is thought that the history of these boilers shows unmistakably the absolute necessity for enforced inspection if explosions are to be prevented. Both boilers gave warning by failing at the furnace crowns. Yet no notice was taken, while it should have been added that the furnace crown of the boiler under consideration had given several days' intimation of the impending explosion by gradually flattening down. Of this the fireman was quite aware, as the information was derived from himself. Yet he went on, risking his own life, as well as the lives of all those working near the boilers.

"The result of the coroner's inquiry was more satisfactory in this case than usual. The jury brought in a verdict to the effect that 'the death in question was the result of scalding, consequent on a boiler explosion on board the steam tug, the boiler plate not having been thick enough to withstand the pressure of the steam;' to which they added that 'the boiler was not in a fit state to be worked.' This is a plain and straightforward statement. It would be well if such were more frequent, *i.e.*, provided that explosions are to be allowed to continue. But had the owner of the steam tug been compelled to place his boilers under competent inspection, the dangerous condition of the boiler would have been pointed out before the explosion instead of after, and thus the lad's life would have been saved and the inquest rendered unnecessary.

ROYAL SOCIETY.

SOME EXPERIMENTS ON THE DISCHARGE OF ELECTRICITY THROUGH RAREFIED MEDIA AND THE ATMOSPHERE.

By Cromwell Fleetwood Varley.

The nature of the action inside the tube is at present involved in considerable mystery, but some light is thrown upon the subject by the following experiments.

The tnbe principally used in these experiments eontains two aluminium wire rings, the one $\frac{4}{10}$th inch in diameter, the other $\frac{9}{10}$th inch, and separated $\frac{8}{10}$th inch, the tube $1\frac{1}{4}$in. in diameter, $3\frac{1}{4}$in. in length; it was one of Geissler's mannfacture, was very well exhausted, and professed to contain hydrogen. A U-shaped glass tube containing glycerine and water was placed in circuit. Two alumininm wires inserted in this tube gave a ready means of reducing or augmenting the resistance at pleasure. Glycerine affords an easy means of producing very great resistanees.

The battery used in this experiment was a Daniell's battery, each eell having a resistance of from 50 to 100 Ohms. The resistance of the glycerine and water tnbe was between 2 and 3 megohms; this latter resistance was made large, in order that the resistance of the tube and battery might be neglected without entailing error.

The following law was found to govern the passage of the eurrent:—1st. Eaeh tube requires a certain potential to leap across. 2nd. That having once established a passage for the current, a lower potential is snfficient to continue the eurrent. 3rd. If the minimum potential, which will maintain a eurrent through the tube, be P, and the power be varied to P + 1, P + 2, &c. to P + n, the current will vary in strength, as 1, 2, &c., n.

It appears that a certain amonnt of power is neeessary to spring aeross the vaeuum; after that, it behaves as an ordinary eonductor, exclnding that portion of the battery whose potential is P, and which is used to balanee the opposition of the tube. In these experiments P was 304 cells. The tube in question eould not be persuaded to allow a eurrent of less than 323 cells to pass; but when once the eurrent had established a ehannel, on lowering tho potential by short eircuiting portions of the battery, so as not to break the circuit, the eurrent would flow when the battery was redneed to 308 cells.

Nature of the Luminous Cloud.

Plücker has shown that when such an exhausted tube, with a current through it, is placed between the poles of an eleetro-magnet, a lnminous areh is produced, whieh arch follows the eourse of the magnetic rays.

As the electro-magnet is magnetised, the tube, which before was full of a luminous cloud, is seen gradually to ehange; the magnet gathers up this diffused cloud, and builds up the areh.

Inasmueh as the electrieity was passing in a eontinnous current from the battery, from wire to wire, it is evident the light is projeeted right and left into those parts of the tube where there is no eleetric current flowing.

To endeavour tó aseertain the nature of this arch, a special tube was constructed. A piece of talc, bent into the form U, had a fibre of silk stretched aeross it; on this fibre of silk was cemented a thin strip of talc, 1in. in length, $\frac{1}{10}$th ineh broad, weighing about $\frac{1}{10}$th of a grain. The tube was sealed np and exhausted; carbonic acid and potash were used to get a high vacnum. When the magnet was not magnetised, the passage of the eurrent from wire to wire did not affeet the pieee of talc. When the magnet was charged, and the luminons arch was made to play upon the lower portion of the tale, it repelled it, no matter whieh way the eleetric eurrent was passing.

When the tube was shifted over the poles of the magnet so as to project the luminous arch against the npper part of the talc, the upper end of the tale was repelled in all instances; the areh when projected against the lower part of the talc, being near the magnet, was more concentrated, and the angle of deviation of the talc was as mueh as 20°. When the upper part of the arch, which was mnch more diffused, was thrown upon the npper part of the talc, it was repelled about 5°.

This experiment, I think, indicates that this arch is eomposed of attennated particles of matter projected from the negative pole by electricity in all directions, but that the magnet eontrols their course, and these particles seem to be thrown by momentum on eaeh side of the negative pole, beyond the limit of the eleetric eurrent.

This areh requires time for its formatiou, for when a charged condenser is discharged through tho tube no arch is prodneed. The areh from the negative pole is a hollow cylinder; the little talc tell-tale agaiust which the arch was projected cut out the light, and a corresponding dark spaee existed throughout tho remainder of the course of the arch.

There was on the talc, at the spot where the areh struek it, a little bright luminous cloud, as though the attenuated luminous vapour was condensed by this material obstruetion.

Great care had been taken not to let the areh strike the single filament of silk which snspended the talc. Having demonstrated that the talc was repelled as described, the arch was allowed to play against the silk fibre, which the author expected wonld have been instantly burnt, such, however, was not the case. Even when a powerful induction-coil replaeed the battery, the fibre remained unhurt.

Comparison of the above Phenomena with Discharges between the Poles of a Holtz's Machine in air.

In the first part of this paper fonr different kinds of discharges *in vacuo* were described. With a "Holtz's" machine, whieh will give 11in. sparks in the air, four well-marked different kinds of discharge have been obtained in the air; one of whieh, the author thinks, will explain the curious and rare phenomenon known as "ball lightning."

In the experiments hereafter referred to, the condensers were, in all cases, attached to the "Holtz's" machine. The first discharge is the long 11in. zig-zag spark or lightning-flash; the seeond is the well-known "brush," which is best obtained by connecting the negative pole of the "Holtz's" machine to the earth; the third kind of discharge is a hissing red flame, $\frac{1}{2}$in. in length, playing abont the negative pole, the positive pole being scarcely luminous at all, and if luminous, at one or two points only; the fourth, or most remarkable phenomenon, is best obtained in the following manner (I shonld here remark that the brass balls on each of the poles are about an inch in diameter):—Tie to the negative pole a small thin strip or filament of wood, 3in. in length, and bent so as to projeet on each side of the negative pole, and a little beyond it towards the positive. On rotating the machine, two bright spots are seen upon the positive pole. If the positive pole be made to rotate upon its axis, the lnminons spots do not rotate with it; if, however, the negative pole, with its filament of wood, be rotated, the spots on the positive pole obey it, and rotate also. The insertion of a non-condnetor, sueh as a strip of glass, in front of the projecting wooden end, obliterates the luminous spot on the positive pole. When the anthor first discovered this, he seeing, apparently, pieces of dirt on the positive pole, wiped it clean with a silk handkerehief, but there they remained in spite of all wiping; he then examined the negative pole, and diseovered a minnte speek of dirt corresponding to the luminons spots on the positive pole.

When the filament of wood is removed from the negative pole, there is sometimes a luminosity or glow over a large portion of the surface of the positive ball. If in this state three or fonr little pieees of wax, or even a drop or two of water, be placed upon the negative pole, corresponding non-luminous spots will be found upon the positive pole, whieh rotate with the former, bnt do not with the latter.

It is, therefore, evident that there are lines of foree existing between the two poles, and by these means one is able to telegraph from the negative to the positive pole to a distanee of 8in. throngh the air, without any other eonductor than that which the eleetrieal machine has eonstructed for itself across the non-condueting gas.

The foregoing seems to the author to give a possible explanation of "ball-lightning;" if it be possible for there to be a negatively electrified eloud sufficiently eharged to produce a flash from the earth to the eloud, a point in the clo̍ud would eorrespond to the wood projection on the negative conductor; if such a cloud exist, a luminons spot wonld be seen moving about the surface of the earth, corresponding to the moving point of eloud over it, and thus present phenomena similar to those described by the privileged few who have witnessed this extraordinary natural phenomenon.

The author has been informed more than onee by captains of vessels, that when men have beeu struek by lightning, a slight burn has beeu left upon the skin of the same shape as the object from whieh the discharge flew. In one instance he was informed that some brass nnmbers, attached to the rigging from which the diseharge passed to the sailor, were imprinted upon his skin.

It is now seen that this is perfectly possible if the discharge be a negative one, that is, if the man be + to the brass number.

INSTITUTION OF CIVIL ENGINEERS.

TRAIN RESISTANCE ON RAILWAYS.

By Mr. W. Bridges Adams.

In this communication the author stated the general principles that should obtaiu in redueiug train resistanee to a minimum, and in so doing the permanent way was regarded as an integral part of the train, without which it would not work at all. If the true principles of construction were aeeurately followed, resistanee—other thau that of gravity—should

be reduced to the single element of axle friction. The proper area of axle bearing was defined, with a proposed plan of axle of tubular form—a true cylinder throughout; the wheels with long bosses revolving independently on the axle, and with ample collar bearing to prevent end wear of the brasses, the hollow of the axle serving as a magazine for a large supply of oil running for a very long time, and it was claimed that such an axle would be practically unbreakable. To get rid of flange friction against the rails, it was stated that the vehicles should have their wheels and axles applied to the frames in such a way—'caster' radial—that under all circumstances each pair of wheels should be parallel to the rails, whether on curves or on straight lines, with the axles pointing truly to the centres of curves, or rectangular to the rails. In one example, for a wagon frame, the springs were shown fixed to the wagon frame with the wheels and axle boxes sliding beneath them, guided by the flanges against the rails. In another, the springs were fixed to the axle boxes, the load being suspended by long shackles, giving very sensitive movement in response to flange guidance. In a third mode it was shown how two pairs of wheels might be coupled together, at each end of a long train, while providing free movement on the sharpest curves by the combination of the 'caster' radial movement with long vertical spring shackles. The importance of self-acting continuous breaks through the whole train, arresting it in the same time and proportionate space as a single vehicle, was also insisted on, as well as the desirability of applying the wheel tires elastically, instead of rigidly, thereby preventing the risk of bursting, and elnding blows, vibration, tire friction, and noise. The principles assumed for the structure of permanent way were, that it should be non-deflecting, either vertically or laterally, by depth of rail, and with a sufficiently solid head to prevent crushing under the wheels; the mode of applying the rails in their supports being such as to prevent their escaping in case of breakage; the fastenings simple, and so arranged as to lay into sharp curves where required; the types of parts as few as possible in number, and also the total number per mile; and that it was desirable to have no brittle parts, and no timber or rotting material. The plan shown was wholly of wrought-iron, practically elastic in the sleepers, which keyed firmly into the ballast; surface packed with the minimum of labour, without any screw bolts, fishes, or timber, and with only four types and 10,000 parts per mile, being one-sixth less than the ordinary Vignoles' rail and sleeper; the total depth of the rail being 7in., and thus nearly double the vertical strength of the ordinary rail, 5in. in depth. The question of engine haulage was then dwelt on. The radial engine for curves of 4 chains radius, as used on the Great Northern, the London, Chatham and Dover, and the Metropolitan railways, was shown with four radial trailing wheels instead of two, adapting it for 2,000 gallons of water and long journeys, without a tender. The four cylinder bogie engine was analysed and compared with two twin engines coupled together, and the advantages and disadvantages discussed. A new class of engine, adapted to give great increase of power and steadiness, was described, in which four cylinders might be used without causing oscillation. The engine had eight driving wheels, the four central flanged, with a sufficient length of wheel base for steadiness. and the end wheels with plain tires, adapted to run without flange friction round curves of 3 chains radius. The cylinders were placed at the central length of the frame, equidistant between the four wheels—two on each side, one under the other; the two pistons on each side working in opposite directions, and thus neutralising oscillation, each piston working a pair of coupled wheels. The engine might be worked by one set of eccentrics on the forward axles, but in case of an irregular slip of the wheels interfering with the due entrance and exit of the steam, eccentrics could be used to each pair of cylinders, and either pair have the steam shut off at pleasure, by the driver on the foot plate, when the full power might not be required. An express engine on a similar plan might have the four end wheels drivers, and the four central wheels sliding laterally to suit curves. It was shown to be important to distribute the load over eight driving wheels to save destructive weights, using smaller cylinders and lighter moving gear, while retaining great power, and that the general system of minimum resistance of the trains and the increased power of the engines would enable a larger coal traffic to be carried on at a reduced expense. The desirability of using liquid fuel for lambent flame in the engines, and also of using the steam twice over, from small cylinders to large ones, on the improved system, was also dwelt on.

At the meeting on Tuesday the 7th ult., Mr. Charles B. Vignoles, F.R.S., President, in the chair, twenty-eight Candidates were balloted for and declared to be duly elected, including three Members, viz.: Mr. William Crouch, Resident Engineer of the Glasgow City Union Railway; Mr. John James Montgomery, Town Surveyor and Engineer to the Corporation of Belfast; and Mr. Charles George Napier, Chief Engineer of the Southern Division of the Great Southern and Western Railway of Ireland. Twenty-five gentlemen were elected Associates, viz.: Mr. Guybon Damant Atherstone, Graham's Town, Cape of Good Hope; Mr. Thomas Aveling, Rochester; Mr. Charles Colson, Superintending Civil Engineers' Office, Portsmouth Dockyard; Mr. Henry Crabtree, General Manager and Agent of the Northern Railway of Buenos Ayres; Mr. Alexander Milne Dunlop, Westminster; Mr. John Eunson, Engineer of the Northampton Gas Works; Mr. Martin John Farrell, Wexford; Mr. George Fowler, Resident Engineer of the Hucknall Collieries, Nottingham; Mr. John Russell Freeman, Westminster; Mr. William George Freeman, Penryn, Cornwall; Mr. Frank Alexander Brown Geneste, late Contractor's staff, East Hungarian Railway; Mr. James Metcalfe Hawkins, Superintending Civil Engineers' Office, Portsmouth Dockyard; Mr. Peter Lindsay Henderson, East India Avenue; Mr. James Archibald Hamilton Holmes, Assistant Engineer, Carnatic Railway; Mr. Joseph John Maclean, Carshalton; Mr. Samuel Lack Mason, General Manager of the North British Railway; Francis Ingram Palmer, Nav. Lieut., Lime Street; Mr. Daniel Pidgeon, Banbury; Mr. Robert Carstairs Reid, Edinburgh; Mr. Thomas Miller Rickman, Montague Street, Russell Square; Mr. Berkeley Craven St. John, Resident Engineer of the Great Southern of India Railway; Mr. Joseph Tomlinson, jun., Cardiff; Mr. Douglas D'Arcy Wilberforce Veitch, Stud. Inst. C.E., Resident Engineer, Bristol and North Somerset Railway; Mr. John Waugh, Gas and Water Engineer to the Midland Railway Company; and Mr. Francis George Wynne, Stud. Inst. C.E., Imperial Arsenal of Zeitim Bournou, near Constantinople.

A report was brought up from the Council stating that, under the provisions of Sect. IV. of the Bye Laws, the following candidates had been admitted Students of the Institution since the last announcement—Messrs. Rodolfo de Arteaga, William Dugald Campbell, Edward Alexander Dunn, Walter Faithfull Garland, Harry Robert Kempe, Henry de Quincy Sewell, and John Slate.

ON THE ARCHIMEDEAN SCREW FOR LIFTING WATER.

By Mr. WILFRID AIRY, Assoc. Inst. C.E.

This communication was intended to supply information regarding the best form of the Archimedean Screw, and its effect when laid at different angles of inclination to the horizon. After suggesting that the previous neglect of this subject was probably owing to the mathematical and practical difficulties attending the construction of screws in the ordinary way, viz.: with the threads at right angles to the surface of the core, the author stated that he had adoped another principle of forming the spiral threads, which would simplify the work of construction and produce a more efficient machine. This was to make the spiral threads on the natural and developable system. If an annular piece of card, or tin, be wrapped upon a cylindrical core, having its edge retained in a shallow spiral groove on the surface of the core, it would naturally take up a fixed and determinate position, not at right angles to the surface of the core but inclined to it; and inclined to it at an angle depending only upon the inclination of the spiral groove on the core. The chief advantage of this spiral thread was that it could be made of a single flat piece of plate, and no work was required except to cut out an annulus, which when wrapped upon the core, gave at once the spiral surface; whereas the threads at right angles to the surface of the core could only be constructed approximately, by using a great number of small pieces. The developable threads also produced a more efficient machine than the threads of the usual form, as was shown by reference to tabular diagrams.

The first set of experiments was made with models of screws of different spiral angles (the "spiral angle" of a screw being the inclination of a spiral line on the core to the lines parallel to the axis of the core) having only one thread a-piece, and the results of these experiments were given on the diagrams; but it was easily seen, that every screw ought to have as many threads as ordinary workmanship and convenience would allow. This was also shown by reference to the results of experiment; and it was concluded that to allow of easy fitting, riveting, and examination, the width of the chambers for a large screw should not be less than 18in. on the square. This condition was used to regulate the number of threads for the models for the second set of experiments.

The second set of experiments was made on six models, whose spiral angles were 20°, 30°, 40°, 50°, 60°, and 74°; the number of threads being varied from four to one. The models were successively inclined at different angles, and the water contained by each model in its different positions was measured by a measuring glass. These experiments formed the basis of the investigation, and it was deduced from them:

(1.) That the quicker the spiral, the flatter must the machine be laid to produce its best effect;

(2.) That screws of quick spiral angle, when laid at their best angle of inclination, delivered a far greater volume of water per revolution than those of slower spiral angle when laid at their best angle of inclination.

In order to ascertain the most economical form of screw, it was necessary to investigate the loss of power due to the internal friction of the water and the external friction on the gndgeons for each machine. This was done by calculation, and the results were obtained numerically for screws of ccrtain specified size, lifting to a height of 10ft. The frictional drawbacks thus obtained were applied to each machine when laid at its best angle of effect, and the efficiencies of the different screws were then calculated. The result showed, that the machine whose spiral angle was 30° was the most economical, but that the machine whose spiral angle was 40° approached it very closely. The best angles of inclination for these two machines were respectively 25° and 30° to the horizontal. In the most favourable case, the useful effect of the screw appeared at 88 per cent., and it was concluded that, after making allowance for certain small losses referred to, the useful effect of a well-constructed screw should not be less than 85 per cent. Reference was then made, by way of comparison, to other machines commonly used for low lifts, viz.: suction pumps, centrifugal pumps, open Archimedean screws, scoop wheels, chain pumps, and Persian wheels; and the paper concluded by pointing out the various advantages of the Archimedean screw, more particularly as regards its durability, simplicity, and useful effect. The communication was illustrated by the series of models from which the results were obtained, and also by a screw, 5ft. in length, constrncted on the system of threads advocated by the author. A model was likewise exhibited, to show the improvements which might be applied to obviate the defects of scoop-wheels, as at present constructed and mounted.

CENTRIFUGAL PUMPS.

By Mr. D. Thomson, Assoc. Inst. C.E.

In this communication a short sketch was given of the early history of centrifugal pumps, and it was stated that their practical introduction as useful machines dated from the Exhibition of 1851. The author attributed to the late Mr. J. G. Appold, Assoc. Inst. C.E. the principal merit of bringing them to such a stage of perfection as to make them generally available. Mr. Appold made numerous and careful experiments, and the results thus arrived at had been confirmed by the author's experience.

The practical rules of construction were thus stated:—

1°. The arms of the fan were curved backwards, according to principles of construction which were explained by diagrams. The depth of the fan was one-fourth of the diameter, and the central opening for the admission of the water was about 9-16 of the diameter. The space allowed in the case round the fan should be of ample dimensions.

2°. The best duty was given when the speed of the periphery of the fan exceeded the velocity of a falling body, due to the height of the lift, by from 6ft. to 8ft. per second.

3°. A fan 12in. in diameter, and proportioned as described, would discharge 1,200 gallons of water per minute.

4°. If the diameter of the fan was varied (the speed of the periphery and the lift remaining the same) the delivery of water was increased or diminished directly as the square of the diameter.

5°. When a centrifugal pump, properly proportioned, was worked by a steam engine, the duty that might be realised ranged from 55 per cent. in the smaller sized pumps to 70 per cent. in the larger machines, of the power shown by tho indicator diagrams.

Tho theoretical principles on which the curves of the arms should be formed were explained and illustrated by diagrams, and easy methods were described of arriving at close approximations to these curves by arcs of circles. The conditions under which centrifugal pumps could be most advantageously used were stated to bo when the lifts were low, not exceeding 30ft. and especially when the lift was also variable, as the centrifugal pump had a self-adjusting property, by means of which as the lift diminished the quantity of water discharged increased. The tabulated resnlts of experiments made with centrifugal pumps for emptying graving docks at West Hartlepool and at Leith, showed this self-adjusting quality of tho pump, and generally illustrated tho principles explained in the paper. Drawings were given of three different kinds of centrifugal pumps that the author had made, adapted for different circumstances, and the special advantages of each were explained.

A note was appended to the paper, embodying a theoretical investigation as to the statical height of the column of water that a centrifugal pump should sustain by a given speed of the fan, and this was shown to be expressed by the formula

$$S = 9{\cdot}82\sqrt{h}$$

where S = the speed of the periphery of the fan in feet per second, and h = the head of water supported by the pump in feet, no water being discharged.

It was shown that, owing to the water exterior to the fan being carried round by fluid friction, the speed of the periphery must always be less than this, and in the smaller pumps it was found experimentally to be more nearly expressed by the formula

$$S = 8\sqrt{h}$$

ROYAL GEOGRAPHICAL SOCIETY.

ON THE RECENT GERMAN ARCTIC EXPEDITION.

By Captain Sir Leopold M'Clintock.

The expedition sailed from Bremen, in the presence of the King of Prussia, on the 15th of June, 1869, in two vessels; one the *Germania*, a steamer of 143 tons and 30 horse-power, the other the *Hansa*, a sailing vessel of 242 tons. The undertaking was supported by public subscription in Germany, and originated in the spirited advocacy of Dr. A. Petermann, who had conceived that an open sea existed round the Pole, which could be reached by persevering attempts to pass the outer girdle of ice which surrounded it. The expedition was not successful in its main object, although minor discoveries of great interest had rewarded its efforts. The *Germania* reached its most northerly point (75° 31′) between the 10th and 15th August, wintered on the coast of Sabine Island, and despatched sledge-parties along the coast northward, which reached, on the 15th April, 1870, 77° 1′ N. lat., and 18° 50′ W. long. In the following summer a deep fiord was discovered, penetrating far into the land between Capes Franklin and Humboldt, surrounded by a picturesque Alpine country, with one peak 14,000ft. high. The temperature of the air here in August was 54½° Fahr., and the shores abounded in reindeer and musk-oxen. The *Germania* reached Bremerhaven on her return September 11th. The *Hansa* was not so fortunate. It parted from the sister-ship in the ice-fields off the coast of Greenland, and all efforts to reach the land were frustrated. The winter caught the vessel in the midst of the ice; and on the 19th of October, 1869, it was crushed, during a storm. between immense floes, and finally wrecked. The crew escaped, and wintered on an ice-floe, on which they were floated, southward in the spring, and from which they escaped to Fredericksthal, in Southern Greenland, in their boat, after spending 200 days on the ice, with fearful sufferings.

The following new Fellows were elected:—Sir Cecil Beadon, K.C.S.I. (late Governor of Bengal); John Cleghorn, Esq.; James Dentry, Esq.; Edward Fane, Esq.; M. Gray, Esq.; J. E. Green, Esq; Captain Robert Hall, R.N., C.B.; Henry H. Kennedy, Esq.; Geo. Kenrick, Esq.; G. A. Rooks, Esq.; W. E. Stark, Esq.; R. Stein, Esq.; G. B. C. Yarborough, Esq.

The sixth meeting of the present Session was held on Monday evening, the 13th ult., Major-General Sir Henry C. Rawlinson, K.C.B., Vice-President, in the Chair.

A letter was read from Mr. Churchill, Consul at Zanzibar, mentioning the despatch of further stores and men to Dr. Livingstone, who was stated to have arrived at Ujiji from his journey to the country of the Manime or Manyema, a cannibal tribe to the west of a new lake beyond Tanganyika. The chairman remarked that Mr. Churchill's letter was of elder date by three weeks than the one from Dr. Kirk, communicated by Sir Roderick Murchison to the "Times," in which the traveller was said to be expected at Ujiji, but not to have actually arrived there. The chairman then read letters from India on the subject of the murder of Mr. Hayward, the society's envoy in Yassin, last August. The letters were preceded by one from Lord Mayo to Sir Roderick Murchison expressing the writer's grief on receiving news of his illness, an enclosing an account of the finding of Hayward's body. The detailed account of these transaction was sent by Mr. Frederick Drew, an English geologist in the service of the Maharajah of Cashmere, who was sent by the Maharajah into Gilgit to inquire into the circumstances of Hayward's death; and who ascertained that the deed was perpetrated at Darkot, by a body of men sent for the pnrposo by Meer Wulli Khan of Yassin. The body was recovered by Gufar Khau, by the Maharajah's orders, and buried at Gilgit on the 27th October last. The chairman callod atten-

tion to the straightforward account of this lamentable transaction, given by Mr. Drew in his letter to Sir Roderick Murchison, and stated that grave doubts were still entertained in India as to the innocence of the Maharajah's government in the matter. Sir Donald Macleod, late Governor of the Punjab, stated that he knew Mr. Drew, and could speak as to the credibility of his narrative.

A paper was read on "The Great Kaieteur Waterfall of British Guiana," by Mr. Charles B. Brown, of the Geological Survey of the Colony. This lofty and picturesque waterfall was discovered by Mr. Brown in April, 1870, whilst descending the Potaro River, a western tributary of the Upper Essequibo. It is formed by the River Potaro precipitating itself over the edge of the sandstone table-land of the interior into the lower country of the Essequibo Valley. He was sent by Governor Scott, in June, to make a second visit and obtain accurate measurements of the falls, and was then accompanied by Sir George Young, Mr. Mitchell, and Mr. E. King. The total height was found to be 822ft.: the width of the river at the edge of the fall 123 yards; and the depth of water near the edge 15ft. 2in., the level being at that season 5ft. below that of the rainy season. Mr. J. G. Sawkins, the Director of the Geological Survey of British Guiana, exhibited a series of most effective water-colour drawings of the falls and neighbouring country, and mentioned the peculiar character imparted to the scenery of the country by the long flat-topped mountains with precipitous sides. Mount Roraima was the most remarkable, rising like a huge mass of masonry above the surrounding country. Its height was 7,500ft. above the sea-level, and its length, as shown by Mr. Brown, 18 miles; the level summit is inaccessible to man, and upon it rise tributaries which flow different ways to feed the Essequibo, the Orinoco, and the Amazons; these streams, in descending from the plateau, forming in some cases waterfalls having a leap of 1,500ft.

The following new Fellows were elected:—Major N. M. Bell; H. M. Blair; Henry Blyth; Charles Wynne Finch; Rev. R. V. French; W. Huddlestone; Major W. W. Knollys; Henry Mawbey; Douglas Merritt; E. A. C. Schalch; John Taylor; T. S. Townsend; Captain E. F. Trivett, R.N.R.; Rev. James Wallace.

ON SOME FALLACIES CONNECTED WITH SHIPS AND GUNS.

On the 11th ult., a lecture on this subject was delivered at the Royal Institution by Mr. E. J. Reed, C.B., F.R.S. The fallacies connected with ships to which the late Chief Constructor drew attention, grouped themselves chiefly about that question of stability which the loss of the *Captain* had recently brought into so much prominence. In its simplest form, the stability of a ship may be considered as the result of the total weight of the ship acting downwards through her centre of gravity, and of her total buoyancy, equal to the weight, acting upwards through a centre situated at a short variable distance from it, this distance defining the leverage with which either force acted about the other. The weight of the ship being the same, whatever the inclination might be, the distance in question, viewed as a lever, might be regarded as itself indicating the degree of "righting force" which the ship possessed. The actual lengths were given for the *Captain* for all degrees of inclination at intervals of 7 degrees, and were as follows: At 7 degrees its length was 4¼in.; 14 ditto, 8¼in.; 21 ditto, 10¼in.; 28 ditto, 10in.; 35 ditto, 7¼in.; 42 ditto, 5¼in.; 49 ditto, 2in.; 54½ ditto, *nil*. It will here be seen that the length of the righting lever, which Mr. Reed spoke of as the "arm of safety" of the ship increased up to 21 degrees of inclination, and then began to decrease, the cause of this being next explained, and shown to result solely from the lowness of the freeboard. All the time the ship had bulk to immerse on the depressed side the buoyancy went on increasing on that side, and the lever in question lengthened. When she had no more side to immerse, but was still inclined further by the wind, the ship began to sink lower in the water, and re-immerse the opposite side, and consequently, the buoyancy was gradually transferred back to that side, the lever meanwhile shortening, and the power of the ship to resist the wind diminishing. The "arm of safety," consequently, never reached a greater length than 10¼in., became only 5¼in. at 42 degrees, and disappeared at 54½. This state of things was then compared with the *Monarch's*, The lengths of the corresponding levers in her were given as below: At 7 degrees, 4in.; at 14, 8¼in.; at 21, 12¼in.; at 28, 18¼in.; at 35, 21¾in.; at 42, 22in.; at 49, 20in.; and at 54½ degrees, 17½in. In this ship, therefore, the "arm of safety," which is rather less than the *Captain's* at small angles of inclination, instead of shortening like hers when only 10¼in., goes on lengthening to very nearly double that amount, attaining its maximum only at about 40 degrees—an enormous angle for a ship under canvas—and even at the angle of 54½ degrees, where the *Captain's* leverage had disappeared altogether, the *Monarch* possessed nearly double the greatest amount of stability which the *Captain* had ever possessed. These figures fulfil the double purpose of showing that the two ships were remarkably alike in stability all the time the low freeboard did not interfere, but as soon as that began to play its part the resemblance between them ceased altogether. He next proceeded to show the unfitness of the low-sided ship to have her stability substantially corrected by ballast, although a high-sided ship could readily have a deficiency of stability made good by these means. In illustrating this, he compared the stability of the *Captain*, with 400 tons of water ballast admitted into her double bottom, with that of the *Vanguard* class, with their iron ballast as now equipped—about 360 tons in amount. The introduction of the *Captain's* ballast so far improved her as to lengthen her arm of safety by a definite amount at all degrees of inclination, but it left the general character of her curve of stability unaltered. In the case of the *Vanguard*, on the other hand, her leverage of safety went on increasing up to great angles, becoming greater even than the *Monarch's*, and presenting the very opposite conditions to that of the *Captain*. In all the aspects of statical stability, the *Captain*, therefore, stood alone, and bears no analogy or relation whatever to either the *Monarch* or the broadside ironclads. It was next explained by what means the stability of ships is increased, and stated that such an arrangement of weights ought to made as to lower the centre of gravity, and give to a ship of the *Captain's* type a greater degree of safety than she possessed, but that it was not possible, without exact calculations, based on specific designs, to say how low in freeboard it would be safe to go with a given spread of canvas. He incidentally remarked that, as a matter of fact, the *Captain's* centre of gravity was much lower than that of several ironclads, giving the following figures: The *Minotaur*, distance of centre of gravity below load-water line, 1·99ft.; the *Valiant*, 1·89ft.; the *Achilles*, 1·51ft.; the *Captain*, 3·25ft. It might nevertheless have been placed lower if the necessity for doing so had been foreseen. On the other hand, changes involving a raising up of great weights would have been essential in a new ship of the type, because on the eve of the loss, Captain Coles admitted to the commander-in-chief that the guns and turrets of the ship were much too low. Mr. Reed then explained the nature of dynamical stability, and how it was measured, and discussed the effects, first of a rising wind, and then of gusts and squalls upon ships under canvas. He showed that when inclined to 14 degrees the *Monarch* had dynamical stability remaining to enable her to resist a squall of sufficient force, if continued, to hold her over to an angle of 20 degrees or more, and yet to have a large reserve of stability still in store. The *Captain*, on the other hand, was without any such reserve, and would necessarily roll over under such a squall. Exact calculations only could show what reserve of force a ship had, and all these calculations affecting the *Captain* have been made from drawings of the ship as built, since her loss. The necessity for them was not foreseen in the proper quarter.

The fallacies connected with guns which Mr. Reed adverted to led, in his view of the matter, to very serious disadvantages. First, he considered that any and every argument which led to the use in the present day of bronze as a material of gun manufacture was fallacious. Quite recently the Government, in remodelling and extending the field artillery of India and of this country, had ordered the manufacture of bronze guns. Now, gun-bronze is a material having a tensile strength of only 17 tons, which is considerably less even than wrought iron, and not half the strength of steel of suitable ductility. The return to such a metal in these days startled the mechanical world, and occasioned many protests and predictions of failure. He considered it wrong to use an inferior metal when one possessing all the strength of steel in association with the necessary ductility was produced. The mechanical principles on which the service guns and projectiles are made are not, in his opinion, sound. The navy in particular, should be furnished with guns and projectiles of greater range and accuracy than the present, and firing longer projectiles. It was not right to contend, as some did, that because the platform of a ship was not absolutely stable, inferior accuracy in guns should be tolerated.

WATTS AND PHELPS' VARIABLE CUT-OFF.

A description of this ingenious self-acting cut-off gear, which is taken from the *Scientific American*, will, we trust, be of interest to our readers.

The motions of this new valve gear are all positive, and the parts are all not only strong and durable, but easily adjusted to equalize the cut-off at each end of the cylinder. It has nothing about it which seems likely to get out of order, and its operation (as shown by indicator diagrams taken from an engine, with this gear attached, by Mr. F. W. Bacon, whose engineering skill is familiar to many of our readers), gives economical results which justly rank as first-class, notwithstanding its freedom from the complications which, in many kinds of valve gear, necessitate constant attention and frequent repair.

The controlling power of the governor is transmitted through the connecting rod, A, Fig. 1, the sector, B, the connecting rod, C, and the toothed sector, D, to a cylindrical rack turned on the sleeve, E. The sleeve, E, is feathered to the shaft, F, and slides longitudinally when acted upon by the parts, A, B, C and D, while turning with the shaft, F, the rotation of the latter being accomplished through a system of gearing, as shown.

The sleeve, E, also carries two cams, shown in section in Fig. 2, at G, which, turning under the toes of tappet arms, H, Figs. 1 and 2, attached to the vertical stems, I, Fig. 2, of the cut-off valves, J, Figs. 2 and 3, raise the valves and let them fall abruptly at the proper point of cut-off to which they are adjusted.

The cut-off valves, J, are of the "grid" variety, and slide on the backs of the principal valves, which latter are actuated in the usual way from an eccentric on the crank shaft.

The sliding of the sleeve E, on the shaft F, causes the cams to let the cut-off valves fall earlier or later in the stroke, according as varying velocity affects the governor.

If the belt break or any other derangement of the governor occur, the travel of the sleeve, being a little more than the length of the cam, allows the toes of the tappet arms to drop off the cam on to the shaft, closing the cut-off valve ports and instantly stopping the engine. In starting the engine, a lever and cam, K, Figs. 1 and 2, is used to raise the cut-off valve and open the port. The motion of the engine then operating on the governor draws the sleeve along so as to bring the cams under the tappets, and thenceforward the gear works automatically.

It will be seen that this gear can be made to cut off from zero to any part of the stroke desired, and that it can be adapted to many kinds of engines in popular use, with but slight alteration.

Fig. 3 is a horizontal section through the cylinder and valve chest which aids in showing the relations of the parts.

As an illustration of the effectiveness of this valve gear we may say

FIG. 1.

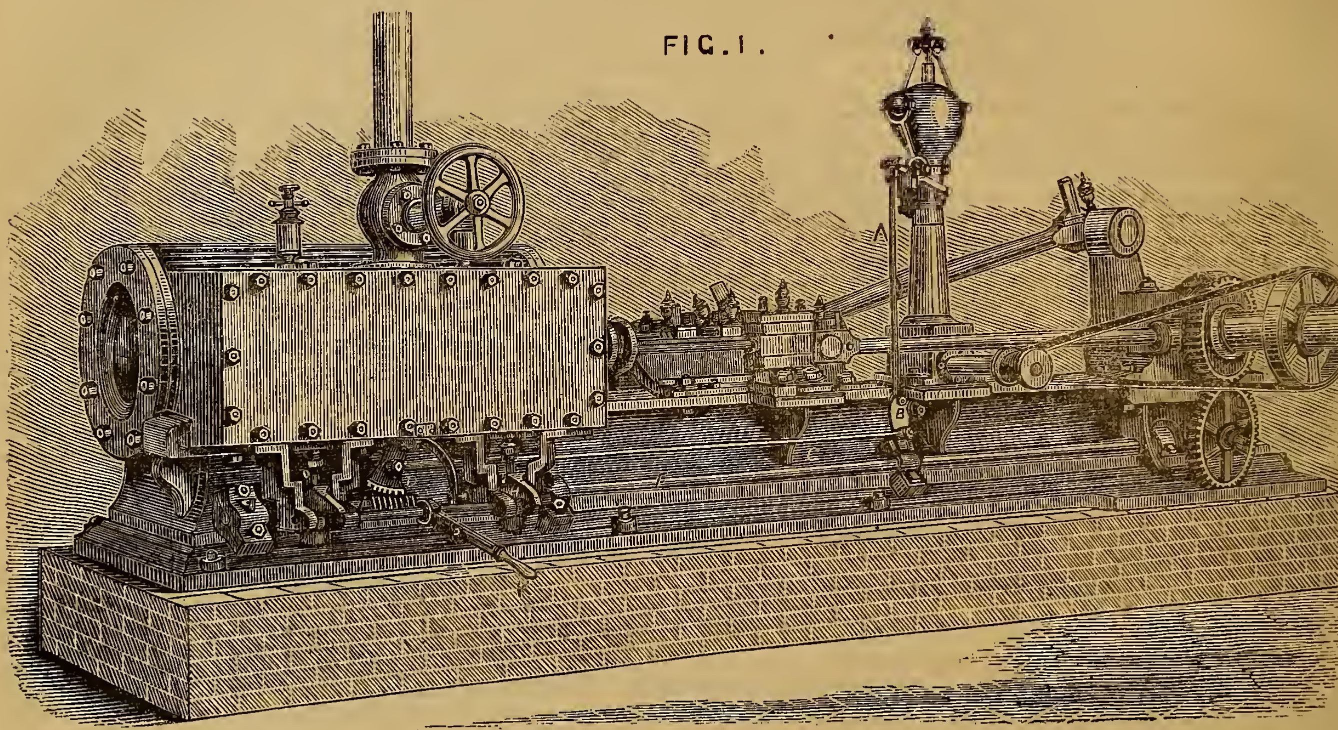


FIG. 2.

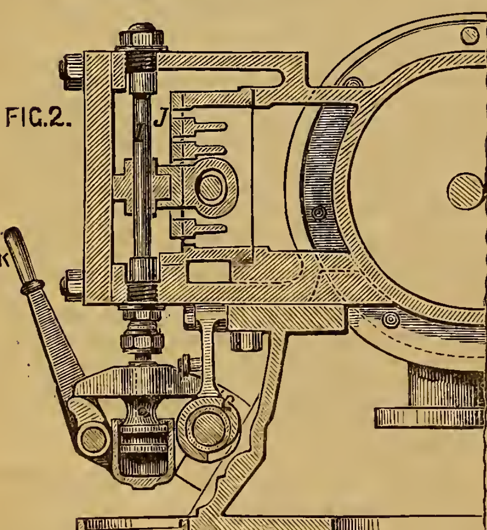
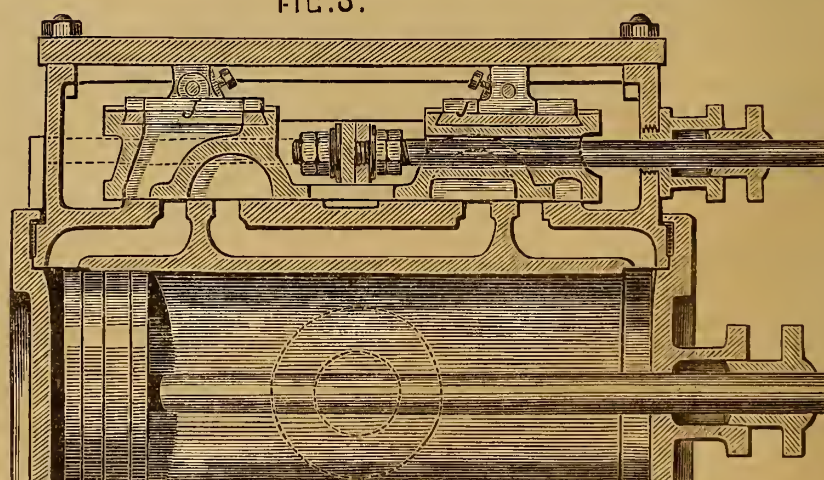


FIG. 3.



that with a double cylinder engine, having cylinders 5ft. by 28in., running at 47 revolutions per minute, in a large thread factory, in Newark, N.J., much difficulty was at first experienced on account of the variable power required to drive the machinery. The variations were so great that it was found impossible to govern the engino by the throttle valve governor.

The application of the valve gear we have described, in connection with a medinm-sized Porter's patent governor, has reduced this variation, so that, including the variation arising from inexactness in starting the engine at the precise moment for work to commence, and stopping at the end of each half day, its maximum irregularity does not exceed ten revolutions per day of ten and one half hours, as determined by a counter, and attested by the engineer in charge.

The cut-off is extremely sharp, as shown by the diagrams, and the work required of the governor is very slight, it being only that required to overcome the friction of the connections, and to move the sleeve longitudinally on the shaft, F, as above described. As a consequence the action of the governor is delicate and sensitive to very slight variations in speed.

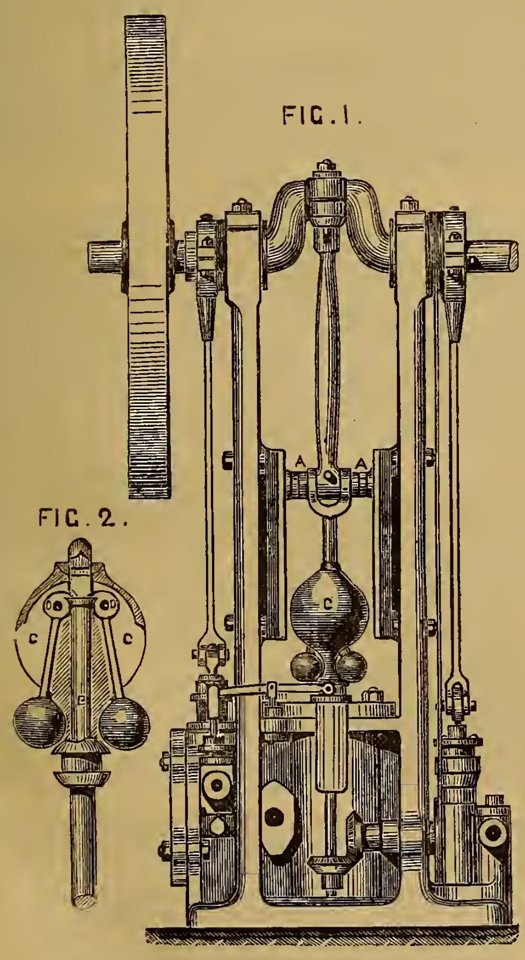
VERTICAL ENGINE WITH HIGH SPEED GOVERNOR.

By Mr. W. N. Nicholson, Newark.

In the account given in The Artizan of January last, of the machinery exhibited at the Smithfield Club Show, an upright engine fitted with a new form of governor was noticed. We have now the pleasure of giving an illustration of this engine, (Fig. 1), together with a detail

FIG. 1.

FIG. 2.



view of the governor (Fig. 2). It will be seen that the engine is of the ordinary vertical construction, with the exception of the arrangement of the guides for the piston-rod crosshead. These are made of a V shape iu which work correspondingly shaped wedges, the advantages of this form of guide being, it is claimed, that they admit of very simple adjustmen by means of screws cut on tho crosshead, and fitted with jamb nuts A A.

The action of the governor will be easily understood on reference to the section shown at Fig. 2. The central spindle B has a square top with a slot cut through it, in which the fingers of tho two governor balls rest as a fulcrum, and being pivotted to the contral weight, C, at the points, D D, as soon as the centrifugal force causes them to rise they lift the weight, C, and with it the lever connected with the steam valve. The amount of lift in this construction of governor being short, it is best adapted to work an equilibrium valve. It will be seen that the constrnction of this governor is exceedingly simple. the number of parts being only six, whereas the usual type of governor has about three times that number, and being upon the high speed principle it is also very sensitive. We consider, therefore, that this invention fully deserves to be included amongst the few really meritorious novelties exhibited at the Smithfield Show.

REVIEWS AND NOTICES OF NEW BOOKS.

The Elements of Algebra and Trigonometry. By W. N. Griffin, B.D. London: Longmans, Green and Co.

This work constitutes another of the series of Text Books of Science, which, as we have already mentioned, is being brought out by Messrs. Longmans. The author has endeavoured in this treatise, to explain the rudiments of Algebra and Trigonometry, so far as to enable practical men to make such computations, as may arise in their business, and we consider has been eminently successful in his attempt. In addition to a comprehensive and very lucid explanation of his snbject, the author has given for practice in the various steps, a remarkably good collection of examples: snch, in fact, as might be naturally expected to arise in the course of business.

Although the work professes to include only Algebra and Trigonometry, there is a very good chapter on Logarithms, in which their utility in the otherwise tedious compntations of reversions, fines for leases, and other constantly recnrring cases in which compound interest obtrudes itself, is very clearly explained.

A treatise on Smoky Chimneys their cure and prevention. By Frederick Edwards. Sixth editiou. London: Longmans, Green and Co.

If there were nothing else to prove that smoky chimneys are, if not universal, at least very numerous, the fact that this useful work has reached its sixth edition, affords tolerably conclusive evidence of this unpleasant state of things. The author has evidently had very considerable experience, which he has brought to bear upon his theoretical knowledge. The list of canses and remedies enumerated towards the end of the book, placed in juxtaposition to one another, will be found exceedingly usefnl to snfferers from smoky chimneys, as they can immediately find out their own peculiar case together with the accompanying remedy.

The Students guide to the practice of measuring and valuing artificers' works. Originally edited by Edward Dobson, Architect. New edition by E. Wyndham Tarn, M.A., Architect. London: Lockwood and Co.

The utility of this standard work is doubtless too well known to need any commendation from us. We may, however, mention that in the new edition, Mr. Tarn has added a large amount of nseful information respecting the technicalities and modes of construction employed in the building trade; besides increasing the number and utility of the tables for facilitating the various calculations aud measurements incidental to the routine of a professional architect. To those unacquainted with this book, we may mention that we have failed to discover anything connected with the building trade, from excavating foundations to bell-hanging, that is not fully treated upon in this valuable work.

Notice has been given in the *Canada Gazette* that application will be made at the next Session of the Dominion Parliament for Acts incorporating companies that intend to extend the Canadian railway system to Manitoba and across the continent. One charter is for a railway proposed to run from Pembina by way of Fort Garry to Lake Winnipeg, or some place on the Saskatchewan near its mouth. The same company will ask for power to improve the navigation of the Saskatchewan. The other project is the Dominion Pacific Railway, from some point on Lake Superior, viâ Red River, across the "fertile belt" to British Columbia. It is likewise intended to improve the navigation of Rainy Lake and Lake of the Woods, and other waters in that line.

NOTES AND NOVELTIES.

MISCELLANEOUS.

The statistics of Lowell. Massachusetts, for 1870, state the capital stock invested in manufacturing companies, 13,650,000 dols.; number of mills, 50; spindles, 526,710; looms, 12,940; persons employed, 14,898. consisting of 6,035 males and 8,863 females; weekly product, 2,240.000 yards of cotton goods, 21,667 yards of woollen goods, 35,000 yards of carpeting, 2,500 shawls, 10,900 dozens of hosiery. Raw material used per week—612,000lb. of cotton, 97,000lb. of clean wool. Goods dyed and printed in the year, 51,691,200 yards. There were used 39,800 tons of authracite coal, 18,100 bushels of charcoal, 1,875 cords of wood, 102,576 gallons of oil, 1,980,000lb. of starch, and 1,275 barrels of flour. The steam-power consists of 82 engines, with an aggregate force of 4,430-horse power. The manufacturing corporations support a hospital for the use of sick and disabled operatives. Lowell has a population of 40,937 persons, and the taxable property is valued at over 25,000,000 dols.

The Secretary of the Wisbeach District Chamber of Agriculture has been favoured with the following letter from Mr. James Duncan, of 9, Mincing-lane, and of the Refinery, Clyde Wharf, Victoria Docks:—"I am very glad to say that I have been successful at Lavenham this year, and I have no doubt that the beet-sugar industry will soon take root in this country. There is nothing to prevent it. Land is cheaper in England than in France, Holland, or Belgium. We can grow quite as good roots as on the Continent, and, by means of deep steam cultivation, very much better. The cost of growing the roots at Lavenham and delivery to the factory ranges from £9 to £11 per acre, including rent, taxes, manure, labour, and cartage. Part of the manure, however, should be debited to the wheat crop which follows. With fair cultivation, an average crop of 15 tons per acre is what may be expected. The price I pay for the roots is 20s. per ton, free of earth and leaves. The farmers get the refuse pulp for feeding the cattle at 12s. per ton. Three tons of pulp are equal to one ton of hay."

It is estimated that the United States' consumption of cane sugar in the year 1870 exceeded 551,000 tons, and that there was also consumed about 32,000 tons of sugar made from malasses, and 23,000 tons of maple sugar, making, in the whole, about 606,500 tons, being an increase of 32,000 tons over 1869. The prolific fields of the Spanish West Indies contribute the great bulk of the supply. The crop of Louisiana in 1869-70 is estimated at 87,000 hhds., a yield thought likely to be substantially exceeded by the crop of 1870-71. It is stated that a little sugar has been made from the beet in Wisconsin, Illinois, and California, but not in sufficient quantity to require more than a passing note of it; and the same remark applies to the yield of sugar from the Sorgo plant. The latter is cultivated chiefly for its syrup, and the manufacture of the former has not advanced yet beyond what may be termed an experimental step.

The Board of Works are shortly about to commence the works for the embankment of the Thames at Chelsea.

NAVAL ENGINEERING.

The 25-ton gun in the fixed turret on board the *Hotspur* has lately been fitted at the Devonport Dockyard with storm chains, which will effectually secure it from the least movement, even in the roughest sea, and it is believed that the vessel might be turned completely over without causing the gun to shift. Around the tube of the gun, at the commencement of its first coil, is a collar, with a chain on each side bolted to the sides of the turret. There are eight chains, four attached to each side of the carriage and slide, which are bolted to the turntable on which the gun is worked—two chains, one on each side of the trunnion connected by a ring near the top, and two chains attached to the slide, one at each end; there is also a bridle (with a chain on each side of it, bolted to the turret), part of which passes through the breeching ring and part over the neck ring of the gun. All the chains have screw swivels, which enable them to be kept uniformly taut. This is said to be the first gun secured in this manner, and certainly the arrangement seems to be perfect.

A rifle tower has been erected on the upper deck of the *Lord Clyde*, armour-plated screw ship, in the basin at Keyham. It is built of wrought iron, ⅝ of and inch in thickness at the ends and half an inch thick at the sides, rivetted to a T iron in the middle, and to angle irons above and below it, and is of the following dimensions:—Height, 11ft. 2in.; length, 9ft.; width, 4ft. 6in. The cover, of ½in. iron, forms an arch of 8in. diameter in the centre, and its flange extends over the top of the tower. between which and the cover there is an opening of 1½in. all round, intended to serve as a look-out, for conning the ship, and as a loop-hole for musketry. Communication with the lower deck is provided for by means of a scuttle inside the tower; the latter being placed immediately abaft the bridge is admirably adapted for the purpose of observation during an action and as a screen for riflemen.

TELEGRAPHIC ENGINEERING.

The estimates of the Queensland Government for 1871 embrace a sum of £32,000, proposed to be expended in the extension of telegraphs. It is also proposed to expend £34,455 for Parliamentary buildings, and £345,668 in the prosecution of sundry railway extensions, viz., Ipswich to Toowoomba, Toowoomba to Dalby, Toowoomba to Warwick, &c.

Notice has been given that the Falmouth Company's cable having been repaired direct submarine communication with Egypt, India, Singapore, and Java is re-established.

A telegraph line from Mier near the Rio Grande to Cerralvo is now completed, and is the commencement of a wire running through Mexico and forming a connection with the lines of the United States. The Government of Mexico is stated to have offered a subsidy of 40 dols., per mile for each mile of telegraph brought into working between Tampico and Matamoras. Efforts are also being made to secure the building of a telegraph line from Mazatlan on the Pacific side to the cities of Sinaloa and Durango. The legislatures of the States of Durango and Sinaloa are extending every possible encouragement to this object.

STEAMSHIPPING.

The steamship *Malta*, of Liverpool, which has recently been supplied by the Birmingham Steam Boiler Company with their patent high-pressure safety boilers of 1,000-horse power, proceeded to sea on the 13th ult to test them. She made the run to Holyhead, returning the same evening, and obtained during the whole trip an increased speed of 1½ knots per hour, a result with which the owners expressed themselves highly satisfied.

The *Black Eagle*, which left Portsmouth for Newhaven to embark Mr. Childers on the 28th of January, had to return to that port in consequence of some defect in her engines. She started again the next morning. In consequence of the engines breaking down the chief engineer has been superseded, and another of her engineer officers has been placed under arrest to await trial by court-martial.

The steamer *Riga*, which is a vessel of 1,324 tons and 180-horse power, Captain Clerk left Shanghai on the 16th of September, Hongkong on the 19th, and Port Said on the 8th of November, for New York, arrived at the latter port on the 11th of January, thus occupying 120 days. The clipper ship *Ariel*, Captain Courtenay, left Yokohama, Japan, on the 21st of September, and arrived at New York on the 16th of January, 117 days out, thus beating the steamer by three days, though the latter came through the Suez Canal thus saving probably 4,000 miles. Another vessel, the *Laufra*, left Macao on the 30th of September, arriving on the 24th of January at New York, beating the *Riga* by ten days. The *Laufra* made the passage by the Cape of Good Hope. Extraordinary as, these passages may seem, they are surpassed by that of the clipper ship *Surprise*, which has just completed her voyage from Shanghai to New York in 83 days, said to be the shortest passage on record either by sailing vessel or steam, *via* the Suez Canal or the Cape of Good Hope.

The low freeboard monitor *Abyssinia*, 1,854 tons, 4 guns, 200-horse power, built under contract with the Hon. Council of India, and Admiralty supervision, for the defence of Bombay, by Messrs. J. and W. Dudgeon at Millwall, arrived out at Bombay on the 23d of January after a very successful voyage, *via* the Suez Canal. She has made the voyage under steam alone, carrying only two signal poles, having been advisedly fitted with no provision for sail-carrying power. She left Greenhithe at noon on the 23d of last November, and called in at Falmouth on the 27th. On the 29th she sailed again, and arrived at Gibraltar at noon on the 6th of December. After 20 hours' stay at the Rock she resumed her voyage, arriving at Malta on the 12th, and leaving again on the 14th. Port Said was reached on the 20th, and she left on the 22d for Suez, which was reached on the 28th, and sailed from again on the 30th. Aden was gained on the 10th of January, and Bombay, as already stated, on the 23d.

SHIPBUILDING.

Another fine steamer has been contracted for by the Inman Company with Messrs. Tod and M'Gregor, of Glasgow. This boat will have a length of 416ft. and 43ft. beam, measuring, by Customs' register, about 4,600 tons.

Messrs. Burns of the Cunard Company have contracted with Messrs. J. and G Thomson, the eminent shipbuilders, for two screw steam-ships, of 2,000 tons each, for a new line of steamers which are to trade between the Clyde and the West India Islands and South America. The first two steamers are to be called *Trinidad* and *Demerara.*

Messrs. Steele and Co. have secured the contract for the construction of a large screw steamer to be added to Messrs J. and A. Allan's North American fleet. She will be 400ft. long and 3,500 tons register, and is, we believe, the largest steamer which has yet been built on Clyde. Her engines, of 500 h.p. (high and low pressure), are to be supplied by Messrs. Macnab and Co., Shaws Water Foundry.

The Liverpool, New York, and Philadelphia Steamship Company (Inman line). with a view to the improvement of the Atlantic service, have just contracted with Messrs. Tod and M'Gregor, of Glasgow, for a steamer of the largest dimensions, having a length of 416ft. and a beam of 43ft. and measuring, by customs gross register, about 4,600 tons, to be ready for the opening of the passenger season next year. This company have also a large new boat ready for the service this spring, and others of their fleet have been increased in power and capacity.

LAUNCHES.

Messrs. William Denny and Bros. launched on the 19th ult an iron screw steamship, the property of the Peninsular and Oriental Steamship Company, forming one of the new class of large vessels with which that company are augmenting their fleet, and the seventh supplied by the same builders. This vessel, the *Indus*, gracefully named as leaving the ways by Miss M'Clure, daughter of Mr. J. H. M'Clure, of Berkeley Terrace, Glasgow, is 360 by 40 by 35ft., and 3,400 tons gross register, and will be supplied with compound surface condensation direct acting engines of 450 h.p., nominal, by Denny and Co. In the equipment of the ship the latest improvements have been introduced, and nothing appears to be overlooked that will facilitate the various movements, while the passenger accommodation and fittings are of the same high class of work and finish for which this company's ships are famed.—Messrs. Thomas Wingate and Co., on the 19th ult launched from their building-yard, at Whiteinch, a screw Hopper barge of 230 tons b.m. and 30 h.p., nominal. This vessel has been built for Barrow-in-Furness, and is the first of an extensive dredge fleet which Messrs. Wingate are building at present for that port, where extensive works are in progress under direction of Messrs. M' Clean and Stileman, C.E.

Messrs. Blackwood and Gordon launched on the 24th January a large steamer from their building yard in Port-Glasgow. Her dimensions are:—Length 290ft.; breadth, 35ft.; and depth of hold, 18ft. with 7ft. depth of spar deck; 1,960 tons. She was built for the firm of Messrs. Burrell and M'Laren, and is for the Eastern trade. On leaving the ways she was named by Miss Paterson, of Glasgow, and was thereafter towed into the builders' dock, where she will be furnished with engines of 250 horse-power, on the compound high and low pressure principle.

The *Canopus*, a fine new iron sailing ship of 920 tons, and highest class in Bureau Veritas, was launched by Messrs. Alex. Stephen and Sons, on the 4th ult., from their new works at Linthouse. The vessel is owned in Germany, and is to be employed in the East India and general trade. The ceremony of naming was performed by Miss Mary Stuart Stephen.

A very powerful new iron dredger of 400 tons, built and engined by W. Simous and Co., was on the 3rd ult. launched from their London Works, Renfrew. It is fitted with engines of 50 horse-power, is intended to work in 27ft. depth of water, and has bucket capacity fit to lift 3,000 tons per day. This vessel is the property of the Harbour Trust of Dundee, and has been constructed under the direction of Mr. Cunningham, their engineer; and is an indication that the commissioners of that enterprising seaport are determined to keep pace with the harbour improvements of the day. Messrs. Simons have also in progress dredge plant for Bristol, Stockton, Barrow-on-Furness, and America.

There was launched on the 7th ult., from the building yard of Messrs. R. Napier and Sons, at Govan, an iron twin-screw gunboat for the British Government, which on leaving the ways was christened the *Kite* by Miss Caroline Macnee. The *Kite* is a duplicate of the *Bustard*, likewise built by Messrs. Napier.

The new paddlewheel despatch vessel *Vigilant* was launched from No. 5 slip in the Royal Dockyard at Devonport. The *Vigilant* was commenced in April, 1870, and will be completed by the end of the financial year, 31st inst. Her dimensions are as follows:—Length between the perpendiculars, 220ft.; length of keel for tonnage, 200ft. 3⅝in. breadth, extreme, 28ft. 2in.; breadth for tonnage, 28ft.' breadth, moulded, 27ft. 2½in.; depth in hold, 14ft. 6in.; burden in tons, 835 21-94ths. The vessel is wooden built of three thicknesses of plane, the two inside built diagonally and the outside put on longitudinally. She will carry two guns, and her engines, which are being built by Messrs. James Watt and Co., will be of 250-horse power, nominal. She is expected to be the fastest of her class (the Helicon class). The *Vigilant* was christened by Miss Ellen Codrington, daughter of the Commander-in-Chief.

TRIAL TRIPS.

The new steamer *Antrim*, bnilt by Messrs. Dnncan and Co., Port-Glasgow, and engined by Messrs. Rankine and Blackmore, Greenock, for the Barrow-on-Furness and Belfast trade, has lately had her speed tried in Morecamhe Bay, when she attained the high rate of 18 knots or 21 statnte miles an hour, proving her to be one of fastest paddle steamers afloat. Her first run from Barrow to Belfast was made in 7 hours 40 minutes.

RAILWAYS.

It is reported that Count Itzenplitz is expected at Versailles to arrange the stipnlations for the cession of the railways of Alsace aud Lorraine, which will become Prussian property. The Eastern Company will receive an indemnity, which will he paid hy the French Government, and the sum will be deducted from the pecuniary indemnity to he paid hy France to Germany.

It is stated that the working expenses on the Great Sonthern and Great Western Railways of New South Wales amount to 68 per cent. of the receipts. On the Great Northern Railway of New Sonth Wales the ratio of the working charges to the traffic receipts is 61 per cent. The Colonial Government, which owns the lines, is ahout to advance the rates charged upon them, as they are much below those current in Victoria.

The navvies engaged upon one of the new lines in progress at Victoria have strnck for 7s. per day, their present wages being 6s. per day. The contractors have resolved to resist the demand, and at the last dates the works were at a standstill

It is stated that the Hon. Frederick Walpole, M.P., is now at Constantinople coudnct ing negotiations with the Turkish Government, on behalf of Mr. W. P. Andrew and others, to obtain a concession for a railway from a port in the Mediterranean Sea to Bussorah, at the head of the Persian Gulf, with the object of ultimately extending the line to Constantinople.

The Lancashire and Yorkshire Company have agreed that £5,000 shall be set aside out of the halance after dividend for the widow of their late chairman. In ennmerating the great services of Mr. Wilson during his office of director since 1846, and subseqnently as vice-chairman and chairman, Mr. Fielden mentioned that he had been mainly instrnmental in working ont the invention for consuming coal in place of coke hy their locomotives, which had effected a saving to the company of £50,000 a year.

The nnmerous accidents which have happened lately have not only aroused the railway travelling pnhlic, hnt have excited the attention of the signalmen and pointsmen of the various railway companies in Yorkshire. A large number of the men in the employ of the several railwav companies from various parts of Yorkshire held a meeting in the Zion School, New Wortley, on the 10th ult. The feeling of the meeting was that the signal and pointsmen especially had to work too many hours, and it was determined that each hoard of directors he petitioned to shorten the hours of lahour and increase the wages of this particular class of servants.

The Central Pacific Railroad, which is an important division of the Pacific Railroad—ahont half—earned last year 7,983,513 dols., as compared with 5,670,882 dols. in 1869, and 2,300,967 dols. in 1868. In the last mentioned year, however, the line can scarcely be considered to have have heen in anything like complete operation.

MINES, METALLURGY, ETC.

New Zealand seems to be rich in coal; almost every mail brings tidings of black diamonds having heen discovered upon her soil. The last advices received from the province of Anckland reported that an extensive deposit had heen found in the hed of a small creek on the west side of the Surrey Redoubt, in a direct north-west line with Porter's Creek, immediately facing Grahamstown. Captain Higgins, a gentleman of experience, has minutely examined the seam, and pronounces it to he of great value and admirahly adapted for steam pnrposes. The coal is found on the property of his Honour the Snperintendent, and is about eight miles from the coast; the country is very level and well adapted for the laying of a tramway. The Snperintendent of the province offers favourahle terms to all who are prepared to work the deposit. The discovery has created considerable interest in the province, in which the consumption of coal is largely increasing.

A seam of rock salt, 4ft. thick, has been discovered near Scone, New South Wales, and is ahont to be worked. A lease of the land has heen bought by Dr. Creed. This is the first instance of salt being found in the colony.

A new process for refining cast iron, has been imported from America by which an enormous saving is to he effected and the operation simplified. Fluor spar—well known as Derhyshire spar—and peroxide of iron—such as the Cumherland hematite—in powder, are mixed and spread over the bottom of the pig-moulds into which the iron from the blast furnace is run. The heat of the iron causes fluorine and oxygen to he liberated; and hy reason of their affinities for silicon and phosphorus these impurities are vaporised. "The resulting metal with respect to silicon and phosphorus is as pure as wrought iron."

APPLIED CHEMISTRY.

The manufacture of iodine from Chili saltpetre already amonnts to 30,000 lh. per annum. The method, invented by Thiercelin, for its reclamation from the crude material is as follows:—The mother liquors, resulting from the manufacture of saltpetre, are treated with a mixture of sulphurous acid and sulphate of soda, in proper proportion, and the iodine will he preciptated as a black powder. The precipitated iodine is put into earthern jars, on the bottom of which are layers of quartz sand, fine at the top and coarse at the bottom; from this it is removed hy earthen spoons into hoxes lined with gypsum, and a greater part of the water thus removed. It is sometimes sold in this impure state, or further purified hy sublimation.

A composition for mixing with white-lead and other colours, to form a paint in lieu of linseed oil, turpentine, and the usual driers, has heen lately brought out. The advantages claimed for this vehicle are, it dries very quickly. In less than half an hour after application it is sufficiently dry and hard to receive another coat. It is perfectly inodorous. A room can be used the same day it is painted. It is peculiarly adapted for painting offices, counting-houses, stairs, ships' cabins, and all work where time is an object. It cleans readily, and is not affected by soap or alkalies. It is economical in use, though the composition is in itself necessarily from the materials employed, dearer than linseed oil. In consequence of the hody contained in the composition, three coats of paint mixed with it are equal to four of ordinary paint; and the great saving in the time always lost by workmen in going from one joh to another, or waiting until such paint is dry, is more than sufficient compensation for the greater original cost. For example, a street-door, which requires the attendance of a workman on five several days to complete the painting and varnishing, can, hy the use of this composition, he painted with four coats and varnished in one day. The material consists of methylated spirit, shellac, and castor-oil.

LATEST PRICES IN THE LONDON METAL MARKET.

	From			To		
COPPER.	£	s.	d.	£	s.	d.
Best selected, per ton	76	0	0	,,	,,	,,
Tough cake and tile do.	73	10	0	74	0	0
Sheathing and sheets do.	75	0	0	76	0	0
Bolts do.	77	0	0	,,	,,	,,
Bottoms do.	77	0	0	79	0	0
Old do.	65	0	0	,,	,,	,,
Burra Burra do.	75	0	0	,,	,,	,,
Wire, per lb.	0	0	10	,,	,,	,,
Tubes do.	0	0	10½	0	0	10¾
BRASS.						
Sheets, per lb.	0	0	7¾	0	0	8
Wire do.	0	0	7	0	0	7½
Tubes do.	0	0	9½	0	0	10½
Yellow metal sheathing do.	0	0	6¾	0	0	7
Sheets do.	0	0	6½	0	0	6⅝
SPELTER.						
Foreign on the spot, per ton.	17	15	0	18	0	0
Do. to arrive.	17	15	0	,,	,,	,,
ZINC.						
In sheets, per ton	23	10	0	24	0	0
TIN.						
English blocks, per ton.	135	0	0	,,	,,	,,
Do. bars (in barrels) do.	136	0	0	,,	,,	,,
Do. refined do.	139	0	0	,,	,,	,,
Banca do.	133	0	0	,,	,,	,,
Straits do.	131	0	0	132	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	6	1	8	6
IX. do. 1st quality do.	1	12	6	1	14	6
IC. do. 2nd quality do.	1	5	6	1	6	6
IX. do. 2nd quality do.	1	11	6	1	12	6
IC. Coke do.	1	2	6	1	4	0
IX. do. do.	1	8	6	1	10	0
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	5	0	,,	,,	,,
Do. to arrive do.	7	0	0	,,	,,	,,
Nail rods do.	7	5	0	7	15	0
Do. Stafford in London do.	7	12	6	8	0	0
Bars do. do.	8	0	0	9	2	6
Hoops do. do.	8	15	0	9	5	0
Bars do. at works do.	7	15	0	8	0	0
Hoops do. do.	8	2	6	8	5	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	6
Bars, common, do.	6	5	0	6	7	6
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	2	6	6	5	0
Do. Swedish in London do.	,,	,,	,,	,	,,	,,
To arrive do.	10	2	6	10	5	0
Pig No. 1 in Clyde do.	2	12	0	3	0	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. Nos. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	10	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	,,	,,	,,
English spring do.	17	0	0	,,	,,	,,
Quicksilver, per bottle	12	0	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	0	0	,,	,,	,,
Ditto L.B. do.	18	2	6	,,	,,	,,
Do. W.B. do.	19	5	0	,,	,,	,,
Do. sheet, do.	18	5	0	18	10	0
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	21	0	0	,,	,,	,,
Spanish do.	17	10	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less.

LIST of APPLICATIONS for LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated January 17th, 1870.

117 J. Horrocks—Metallic piston
118 J. A. Carteron and E. Rimmel—Extinguishing fire
119 C. H. Roeckner—Woollen-faced rollers
120 G. E. Casebourne—Steering vessels
121 J. Starley—Sewing machines

Dated January 18th, 1871.

122 A. Field—Cases or envelopes for night-lights
123 J. Harris—Steam boilers
124 G. Haseltine—Preventing fraud
125 G. Haseltine—Shot-pouches
126 G. Haseltine—Table-spoons
127 R. H. Leask—Regulating speed of motive-engines
128 J. Clark—Railway breaks
129 J. White—Oil cans
130 T. Richmond and W. B. Cooper—Looms
131 S. A. Parley—Magnetic telegraph apparatus
132 J. L. Norton and G. Hawksley—Mills

Dated January 19th, 1871.

133 W. Williams—Cutting coal
134 J. J. Long—Dividing timber
135 T. Corbett—Ploughs
136 E. Foulger—Tramways
137 J. Davies—Folding and cutting machines
138 G. A. Reid—Protective dip
139 L. B. Schmolle—Delivery of thread from reels
140 E. Keirby—Fog and danger signals
141 W. R. Lake—Ageing liquors
142 W. R. Lake—Telegraph cables

Dated January 20th, 1871.

143 P. Brotherhood and G. D. Kittoe—Flow of fluids
144 W. Guest and E. Craddock—Covering for telegraph wires
145 C. D. J. Seitz—Fibrous pulp
146 T. B. Johnston—Treasure safe for ships
147 J. Simpson—Skates
148 H. Lomax and J. Lomax—Sewing machines
149 W. Robinson—Manufacture of iron
150 G. Warsop—Air engines
151 J. Hoskin—Controlling the flow of liquids

Dated January 21st, 1870.

152 A. Porecky—Venetian blinds
153 A. Jacob—Scent bottles, &c.
154 J. E. Wilson—Railway engines
155 R. Turnbull—Pontoons, &c.
156 F. Hogg—Fireplaces
157 W. Winter—Sewing machines
158 G. Green—Separating ores
159 T. B. Sharp—Injectors
160 J. C. Ridley—Iron and steel
161 H. Colls—Horse-shoes
162 J. H. Brown and J. Bowron—Paper
163 R. H. Warwick—Apparatus for the supply of hot water
164 A. K. Rider—Air and gas engines
165 N. Clayton and J. Shuttleworth—Thrashing and winnowing machines

Dated January 23rd, 1871.

166 C. Hunt—Distribution of gas
167 B. J. Bing—Artificial teeth
168 F. Tayler—Paper fronts
169 G. Gilbert and T. A. Ellis—Rails for railroads
170 H. Walker—Carding engines
171 B. Clarke—Mortice machine chisels
172 R. Roberts and D. Shaw—Looms
173 W. Cochrane—Currents in pipes, &c.
174 J. P. Waterson—Hot-water apparatus
175 F. Tommasi—Generating force
176 E. Madge—Circulation of liquids
177 W. E. Newton—Cheese

Dated January 24th, 1871.

178 J. Conlong—Looms
179 J. Cockshoot, T. Wrigley and H. Weathcrill—Railway carriages
180 T. M. Houghton—Indicating angles
181 J. Moore—Boats
182 A. Smee—Supplying towns and villages with water
183 J. Tomlinson and J. Tomlinson—Railway signals
184 W. E. Newton—Meters for measuring liquids
185 C. Ritchie—Utilising heat, &c.

Dated January 25th, 1871.

186 J. H. Finch—School desks
187 W. T. Mann—Breech-loading ordnance
188 J. Blackmore—Cisterns
189 J. Jones—Cutting cigars, &c.
190 B. J. B. Mills—Uppers of boots, &c.
191 M. Chapman—Cases, &c.
192 J. E. Wilson—Railway switches, &c.
193 C. F. De Kierzkowski—Coupling gear
194 V. Pendred—Wheels
195 T. Whitehead—Combing wool, &c.
196 T. Whitehead—Treating china grass
197 G. Bucney—Iron tanks
198 C. E. Spagnoletti—Signalling
199 F. Walton—Block printing apparatus
200 C. E. Webber—Forcing air
201 R. Porter and T. Lane—Gas for illumination

Dated January 26th, 1871.

202 S. Wilkes—Spindles and their knobs or handles
203 M. Morris—Looms
204 L. Merckelbagh—Breech-loading firearms
205 R. F. Smith—Metallic antimony
206 E. H. Smith—Printing presses
207 W. W. Pilkington—Manufacture of glass
208 A. A. Downes—Ear-rings
209 J. G. Tongue—Sewing machines
210 C. Lungley—Apparatus for dredging
211 E. W. Buller—Attaching door and other knobs and handles to spindles
212 A. V. Newton—Steam boilers
213 H. W. Whitehead and R. Ackroyd—combing wool, &c.

Dated January 27th, 1871.

214 J. G. Boehringer and C. Krall—For facilitating locomotion
215 J. Nuttall—Looms
216 G. H. Haywood and F. Parker—Stove grates
217 R. A. Gooding—Cork drawer
218 S. W. Norman—Steering tramway cars
219 A. Tatham and H. Tatham—Means in taking up the threads in warp machines
220 W. Shanks—Cutting metal bars
221 R. Boyle—Ventilators
222 J. C. Ramsden—Looms
223 H. Bessemer—Ascertaining the distance of objects

Dated January 28th, 1871.

224 J. L. Mills—Match boxes
225 J. Broad—Paper pulp
226 J. Clegg and G. A. Clegg—Fastening boots and shoes
227 E. W. Allin—Composition for covering paper
228 W. Knowles and M. Hetheriugton—Covered rollers
229 J. G. Jennings—Waterclosets
230 W. H. Orth—Sweeping machines
231 W. C. Stiff—Bale tics
232 J. W. Butler—Stoppers for bottles, &c.
233 R. Nicholas—Cylindrical boxes
234 W. R. Lake—Covering surfaces
235 G. Haseltine—Pillows and bolsters
236 W. Tongue—Pinofortes, &c.

Dated January 30th, 1871.

237 G. H. Funck—Vessels for containing volatile oils
238 I. Rebanks—Reservoirs
239 S. Richards—Machines for spinning
240 C. L. Lawrence—Padlocks
241 J. Walkland and J. Unwin—Self-acting fountain
242 J. Macintosh—Life preservers
243 B. Whiteley and G. Harling—Looms
244 W. Lorberg—Utilisation of galvanisers' liquors
245 W. Lorberg—Manufacture of soap
246 W. R. Lake—Combs for worsted machinery
247 C. J. Galloway and J. H. Beckwith—Valves
248 J. Young—Drying glutinous or semi-liquid substances
249 W. Morris and G. Eskholme—Supply of water

Dated January 31st, 1871.

250 T. J. Smith—Mitrailleuses
251 E. C. Hodges—Breech-loading firearms
252 Sir W. Thomson—Transmitting, &c.
253 W. Robinson—Steam trap
254 M Henry—Sewing machines
255 C. Allen—Roadways for rivers
256 W. Gibbs—Preparing flax, &c.
257 E. C. H. Krueger—Fountain pens
258 E. B. Burr—Holding railway and other carriage window sashes
259 A. J. Atkey—Ore-stamping machinery
260 G. E. Jeffery and R. Luke—Portable engines and boilers
261 A. M. Clark—Vapor engines
262 E. G. Durant—Sharpening saws

Dated February 1st, 1872.

263 R. Boyd—Dispersion of sand, &c.
264 H. White—Colonring
265 H. C. Harvey and T. Walton—Mortice locks
266 J. S. Starnes—Fog-horn
267 C. Adams—Envelope or wrapper
268 F. Osbourn—Waistcoats
269 T. C. Fawcett and W. M. Shackleton—Machinery for moulding, &c.
270 L. M. Green—Joint for pipes
271 R. Stewart and J. Wallace—Preparing esparto grass
272 W. S. Holden—Spinning cotton
273 R. Nevill—Manufacture of retorts
274 C. M. Smith—Services or utensils for the wash-stand
275 H. W. Dyer—Apparatus to be used in fixing chairs
276 H. Gardner, R. Lowe, J. Wood, J. Wood and J. Pickering—Spring mattresses
277 H. Davey—Steam engines

Dated February 2nd, 1871.

278 P. Wilson—Bushes for the bungholes of casks
279 A. Annandale—Treating wood, &c.
280 W. Husband—Ships of war
281 W. Randall—Drills
282 J. S. Christopher and J. F. Lackersteen—Screws
283 W. H. Crispin—Machinery for washing and dressing the debris from lead mines
284 P. H. Sharkey—Scale beams
285 E. Tomkins—Warming railway carriages
286 A. T. Becks—Utilisation of tin plate scrap iron
287 J. R. Mottram—Cutting glass
288 D. Sharrocks—Rivets
289 A. V. Newton—Lozenges
290 J. Welcb and C. Laight—Cases for holding needles, &c.
291 R. H. Hughes—Gas regulators
292 C. W. Siemens—Producing cast steel
293 W. R. Lake—Machinery for cutting cloth, &c.
294 W. Lake—Electro-motors

Dated February 3rd, 1971.

295 T. Turner—Rivetted boots
296 H. Starr—Buoyant mattress
297 P. Sherwin and J. M. Sutton—Sewage matters
298 W. Walker—Steam pumps
299 J. Oldroyd, M. Oldroyd and J. Woodcock—Opening and stopping down fabrics
300 S. Corbett—Pulping turnips
301 O. Phalp—Improved composition

Dated February 4th, 1871.

302 J. W. Chambers and F. E. Elton—Artificial fuel
303 R. Curtis and W. Greasley—Spinning cotton, &c.
304 J. Heginbottom—Steam boilers
305 J. Church—Distilling
306 T. Bell, W. W. Urquhart and J. Lindsay—Power looms
307 R. Girdwood—Steam boilers
308 J. E. Tysall—Ornamenting
309 W. R. Lake—Condensed soup
310 W. Tate—Apparatus for elevating
311 J. T. Smith—Gunpowder

Dated February 6th, 1871.

312 E. Burstow—Improved apparatus, &c.
313 W. Winter—Turning, &c.
314 W. H. Samuel—Matches
315 F. J. Mee—Apparatus for heating

Dated February 7th, 1871.

316 T. Widdowson—Umbrellas
317 I. Farrell—Tiles
318 E. Hutchinson—Treatment of wheat
319 J. Raper and J. Stephenson—Grate bars, &c.
320 G. R. Hay—Dressing millstones
321 R. Winder—Apparatus for composing
322 G. H. Ellis—Fitting soles and heels to boots
323 G. P. Harding—Tell tales

Dated February 8th, 1871.

324 T. Rowan—Pigments
325 A. Morand—Bricks
326 H. Basquit—Drums
327 R. Mallet—Repairing roads, &c.
328 G. E. Hansen—Spars and gear for yachts
329 B. G. Sloper and F. J. J. Washer—Treatment of sewage
330 J. Pumphrey—Watering cans, &c.
331 R. G. Shute—Cutting mitres
332 M. Benson—Castors for furniture

Dated February 9th, 1871.

333 J. Ormerod—Looms
334 P. Holland—Colouring matters, &c.
335 J. Eccles—Looms
336 C. H. Murray—Moulded bricks
337 B. Dew—Manufacture of milanese
338 H. Lightbrown—Measuring, &c.
339 W. R. Lake—Wire fabrics, &c.
340 W. R. Lake—Screw propeller, &c.
341 C. F. Roberts—Life boats
342 H. Wilke and W. Esplen—Safety-valves
343 W. Knowles—Lubricating axles
344 D. Adamson—Steam boilers

Dated February 10th, 1871.

345 R. Smith—Dressing the nap of woollen cloth
346 J. Kenyon—Checking shuttle in looms
347 G. McDonald—Water-tight boot, &c.
348 J, Rattray—Corks
349 H. H. Cochrane—Working switches
350 E. T. Hughes—Breech-loading firearms
351 C. Baly—Deodorising sewage, &c.
352 S. B. Allen—Engine governor
353 I. Greenboam—Overcoats, &c.
354 C. Thomas—Cleansing wool, &c.

Dated February 18th, 1171.

355 F. B. Taylor and W. M. Adams—Connecting a propeller, &c.
356 J. Quin and R. Eastham—Manufacture of hose, &c.
357 A. V. Newton—Windmills
358 G. H. Goodman—Machinery for crushing, &c.

Dated February 13th, 1871.

359 H. J. F. H. Foveaux—Automatic valve
360 C. M. Tate—Asphalte roads
361 F. F. Ommanney and H. Routledge—expansion valves

Dated February 14th, 1872.

362 W. R. Lake—Improved flyer
363 A. Jagger—Combing, &c.
364 E. McConville—Manufacture of sulphuric acid
365 A. R. P. Smith and C. W. Granville—Making paper pulp from wood
366 A. Clegg—Sewing machines
367 V. E. Procter—Splitting, &c.
368 J. Hirst, J. Hirst and J. Hirst—Wringing and mangling machines
369 J. F. Pirouet—Separating pulp, &c.
370 J. Ridsdale—Steam engines
371 A. Millar—Numbering machines
372 A. R. P. Smith and C. W. Granville—Cleaning cotton, &c.
373 G. Haseltine—Telegraphic apparatus, &c.

Dated February 15th, 1871.

374 W. Blandford—Sewing machines
375 T. H. Rushton and R, Tonge—Spinning cotton
376 W. Lockwood—Incrustation in boilers
377 J. Barran and J. Barran—Apparatus for pressing, &c.

FIG. 1.

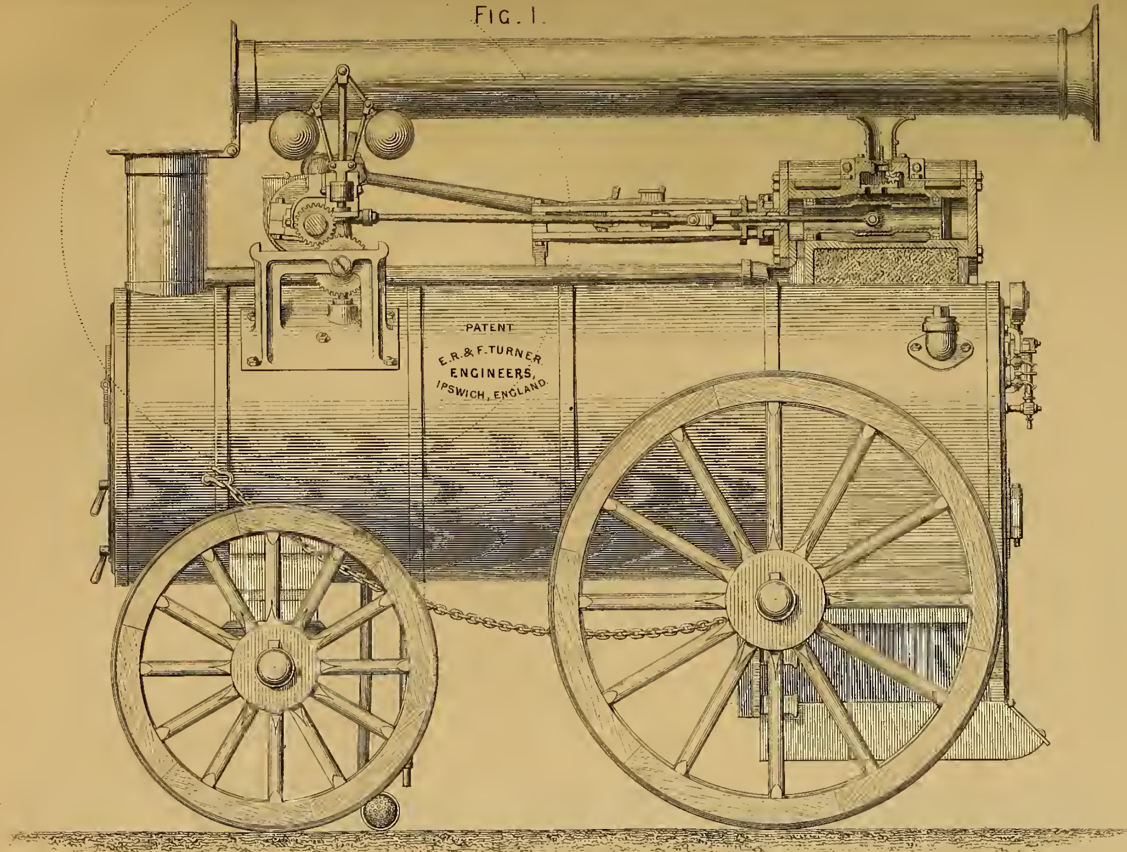


FIG. 3.

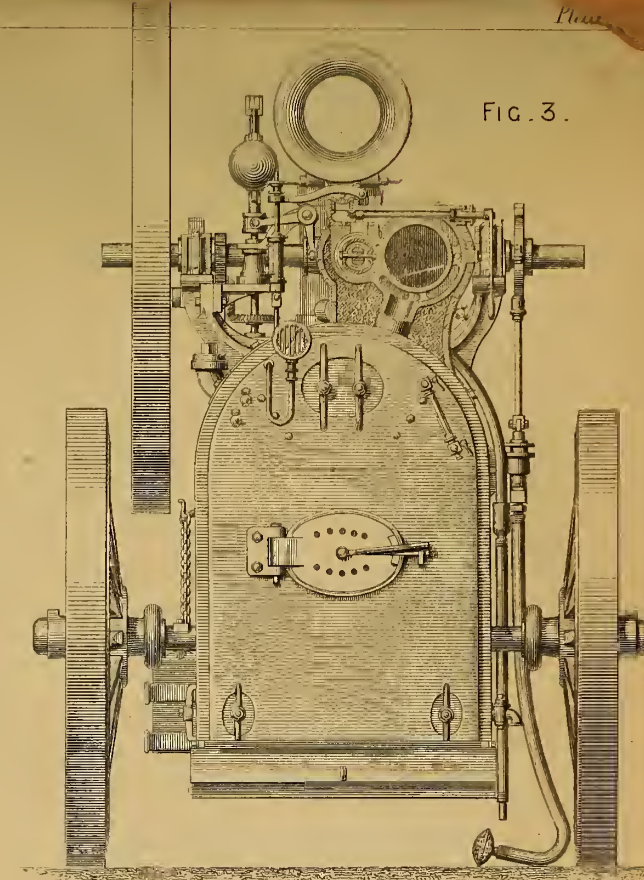
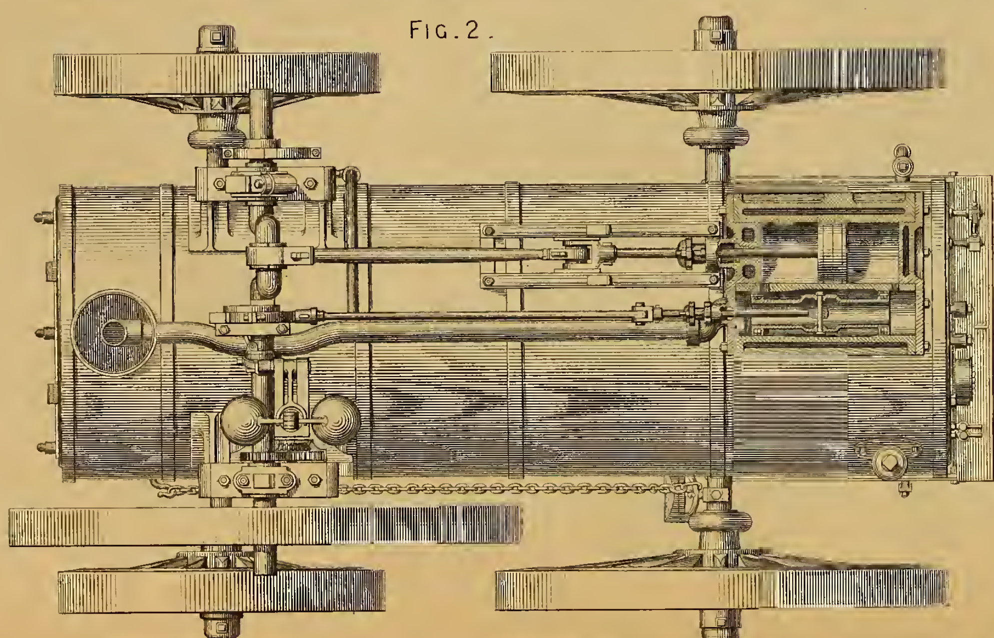


FIG. 2.



IMPROVED PORTABLE ENGINE,

BY

E. R. & F. TURNER _ IPSWICH

Scale $\frac{5}{8}$ in = 1 Foot.

FIG. 4.

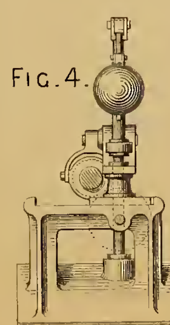
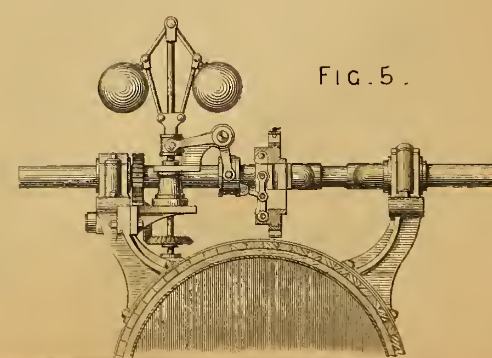


FIG. 5.



P. Soames, C.E. direx

Engraved by G.B. Smith

THE ARTIZAN.

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1st APRIL, 1871.

PORTABLE ENGINE.

By Messrs. E. R. and F. Turner, Ipswich.

(Illustrated by Plate 372.)

Portable engines, although introduced at a much later period than any other description of steam engine, have during the last ten or fifteen years been so universally employed that it appears somewhat strange that so few novelties are ever recorded in their construction. Thus, at the Smithfield Club Show, at the Royal Agricultural Society, and the various local exhibitions of agricultural machinery, the same, or as nearly as possible, the same engines appear year after year, until one feels tempted to write a stock description suitable for all occasions, with the simple variation of dates and localities. This similarity is doubtless partly owing to the comparatively late introduction of portable engines, and therefore of the greater perfection in the original design than was possible in former years; yet we cannot help thinking that the enormously increasing demand for this class of engine should have had a greater effect in stimulating the inventive faculties of the manufacturers in order to meet such demand in the best possible manner. For instance, in most of the agricultural districts in which these engines are employed, fuel is enormously dear, and it therefore becomes of the highest importance that the consumption of that article should be as small as possible. Instead of this, however, we find that, although steam at a pressure of 60 to 100lbs. per square inch is employed, the great majority of portable engines have no provision for expansion further than a common single slide valve, the object of the manufacturer apparently being to turn out a cheap job and make up for its deficiencies by means of paint and polish. It may, perhaps, be objected that this course is the only one open to manufacturers, as the bulk of their customers cannot distinguish between a good engine and a bad one; but at the same time their perception, so far as regards money, is remarkably keen. No doubt this is to a certain extent true, but we have yet to learn that even amongst agriculturalists quality will not in a very short time assert its superiority over price. It is sometimes objected that the comparatively unskilled labour usually employed to drive these engines is unfitted to manage the refinements that are often suggested, but in many cases, such for instance as the arrangement shown in Plate 372, great economy is obtained without entailing any extra attention on the part of the driver.

The portable engine which is illustrated in Plate 372 contains several important improvements by Messrs. E. R. and F. Turner, of Ipswich, having for their object economy of fuel. This is effected by a peculiar arrangement of self-acting expansion gear combined with a long slide.

From the accompanying engravings shown in Fig. 1 a longitudinal and in Fig. 2 a transverse section of the cylinder and steam chest, to an enlarged scale, it will be seen that the slide-valve consists of two pistons, A A, connected the one with the other by a trunk or hollow rod. They work in a cylindrical chamber, and steam is admitted to the chamber between the pistons. The valve-rod giving motion to the slide-valve embraces a pin passing through the trunk or hollow rod of the valve. The steam is admitted into the space between the two pistons while the exhaust pipe passes from one end of the valve chamber, and is in communication with the other end of the chamber by the trunk or hollow rod of the valve. The valve pistons have packing rings, and to secure a clean cut-off these rings are fixed and flush with the body of the piston on the side, A A, next the steam ports, so that the elasticity of the piston, instead of being equal all round, is always towards the ports.

There are other ways in which this end may be attained. Thus, the piston may be solid on the port side, and the springs segments of circles in place of being complete circles.

The steam is admitted by means of a slide valve, shown at B

FIG. 1.

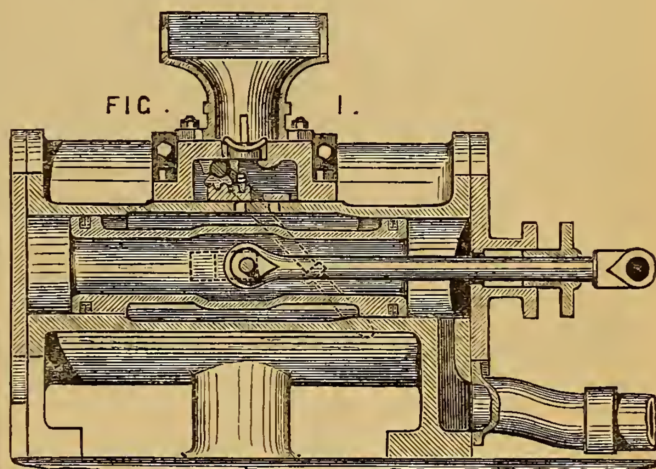
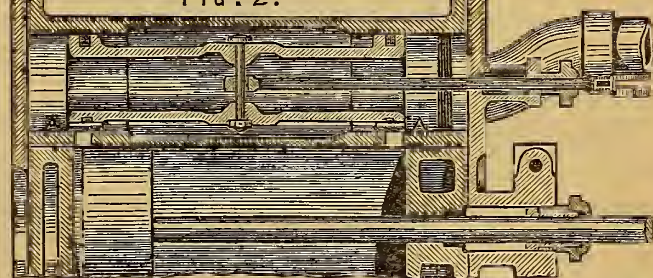


FIG. 2.



actuated by moving a handle, shown in dotted lines, connected to a toothed segment working in a rack at the back of the valve.

The arrangement for varying the expansion by means of the governor is very ingenious, and is so clearly shown in Figs. 4 and 5 in Plate 372, that but little explanation is needed.

The governor by means of a bell crank lever gives motion to a sleeve upon the crank shaft, and a link connects this sleeve to the centre connecting joint of two rule-jointed rods, one of which at its end is jointed to the shaft, and the other to the eccentric, which can slide transversely on the shaft, but cannot turn or move longitudinally upon it. The varying inclinations which the governor gives to the rule-jointed rods causes corresponding variations in the distance between the centre of the crank shaft and the centre of the eccentric, thus varying the stroke of the valve, which, however, always opens the steam ports at the same relative position of the crank. By this means the degree of expansion being entirely under the control of the governor is always adapted to the

amount of work upon the engine, and consequently no extra skill or attention is required on the part of the attendant.

In Plate 372 is shown a side elevation at Fig. 1 with the valve chest in section, Fig. 2 being a plan of the same showing the valve chest and cylinder in section. Fig. 3 represents an end elevation with a sectional view of the cylinder and slide valve, showing also the arrangement of the starting gear. Figs. 4 and 5 illustrate the method of varying the eccentric by means of the governor, as already described.

SUGAR MACHINERY.

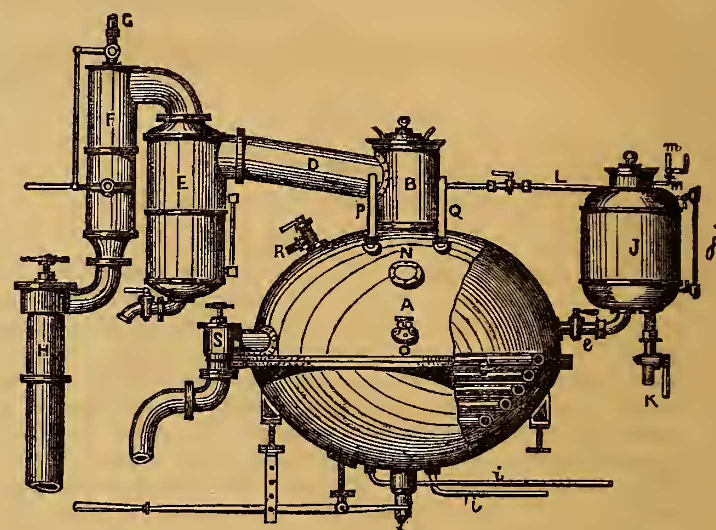
Evaporation.

(*Continued from page* 51.)

We have already described (in The Artizan of last month), some of the most popular methods at present in use for evaporating cane-juice, and considering that they are simple to manage, moderate in first cost, and efficient in their work, it is not to be wondered at that they have obtained a preference over the more scientific method of boiling *in vacuo*; although there is no doubt that this latter process produces the finest sugar. In this country, the vacuum pan (Plate 371, Fig. 3), has long been almost universally employed in refineries, but until the late alteration in the sugar duties, its use was practically excluded from all sugar plantations which depended upon the English market for the sale of their sugar. Hence, but few vacuum pans are to be found in the West Indies, with the exception of Cuba, where the advantages of selling in a foreign market, and (commercially only) of slave labour, enabled the planters to take advantage of this beautiful process. In the rich but swampy sugar estates of Demerara, the vacuum pan is necessarily used to a considerable extent to improve the quality, which would otherwise be very inferior. It has also been extensively adopted in the district of Province Wellesley, opposite to the island of Penang, but in this case the principal amount of the sugar manufactured, goes to the Chinese market, and at the same time skilled Chinese labour may be cheaply obtained for their management. The principle upon which the vacuum pan is founded, is too well-known to require any explanation here, but, we may perhaps for the sake of some of our readers advert to it for a moment. It is found that the boiling point of all liquids varies with the pressure of the atmosphere. Thus, water boils in the open air, at the usual pressure of the atmosphere, or 30in. of mercury, at 212° Fah., but as this pressure is reduced, a corresponding reduction in the temperature of the boiling point takes place, until it descends below 100°, when that pressure is entirely, or almost entirely taken off. As, however, the boiling point of a concentrated solution of sugar is, as we have already observed, considerably above that of water when both are exposed to the pressure of the atmosphere, a similar result of course obtains when evaporating a vacuum. It is found practically that the lowest temperature at which the syrup can be boiled is about 145°, but for the sake of rapidity of evaporation, this temperature is usually considerably exceeded.

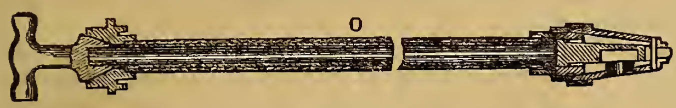
Since the time of Howard's invention (1812), a vast number of differently shaped pans have been tried, and several important improvements in the details been made, many of these modifications being simply designed to suit the particular situation in which the pan had to be placed. One of the most important improvements in this pan was the adaptation of a *Torricellian* tube to assist the air pumps. This arrangement consists in attaching to the bottom of the condenser a vertical pipe of about 33ft. in length, into which flows the condense water, and as it is well-known that a column of about 30 to 32ft. of water will balance the pressure of the atmosphere, this length is sufficient to allow the condenser to discharge itself of water, thereby reducing most materially the work on the air pump. As, however, this arrangement is not usually suitable for the colonies, in consequence of a sufficient height not being obtainable, we have shown in Plate 371, (The Artizan, March 1st), one of the latest, and, we consider, one of the best arrangements there employed.

In order to make the method of working the vacuum pan easily understood, we will with the assistance of the annexed illustration, describe



the various parts. The vacuum pan A is usually made of copper in halves, bolted together as shown, a manhole B being provided for the purpose of cleaning out and repairing when necessary. The lower half of the pan is surrounded by a cast iron steam jacket for the purpose of heating the liquor; this object being further effected by means of a steam coil C, fitted inside this portion of the pan. The pipe D is for the purpose of carrying off the vapour, and in case the ebulition in the pan should be so violent that the liquor primes over with it, a vessel or "safe" E is provided to catch it, when it is returned by means of the pipe and cock *e* into the pan, the amount of the overflow being readily observed by means of a glass gauge attached to the side. The vapour passes into the condenser F, which is constructed similarly to that of a condensing engine, a jet of cold water supplied by the pipe G, being used for condensing the steam; while the pipe H is connected to the air pumps in the usual manner. The steam is supplied to the pan by means of the pipe and stop valve I, and the condense water passes off through the pipes *i* and *i'*, the one being connected to the bottom of the coil, and the other to the steam jacket. A measure J is frequently attached to the pan of sufficient capacity to hold the requisite quantity of liquor for charging it. This vessel is supplied with a glass gauge *j*, for the purpose of observing the height of the liquor. It is filled through the pipe K, a vacuum being formed by means of the air pipe L, carried to the top of the pan and discharged into the pan through the pipe M as required; the small air cock *m* being opened for the purpose of destroying the vacuum when that process is being performed. A glass sight hole N is shown in the upper part of the pan, a similar sight hole being fitted on the opposite side, so that by looking through the one, the other affords sufficient light to enable the attendant to judge the state of the liquor inside the pan. In addition to this, means are provided for extracting a sample of the liquor from inside of the pan, without disturbing the vacuum, by the use of a proof stick, O, and shown to an enlarged scale in the annexed engraving. This consists of a gun metal rod, with a cavity at the lower end for receiving the sample of sugar, and fitting into a hollow casing open at the bottom to the liquor. A plug somewhat similar to an ordinary liquor cock, is accurately fitted to the bottom, and can be turned round by means of the handle of the proof stick. As the aperture

of the plug corresponds to that in tho proof stick, whon it is oponed to the liqnor a portion flows through into this cavity; when, by turning the plug half ronnd, connection with the contents of the pan is cut off, and the portion that has flowed into the cavity of the proof stick can be



safely withdrawn for examination. A thermometer, P, and barometer, Q, are supplied to tho upper part of the pan for the purpose of ascertaining the temperatnre and tho quality of the vacnum inside. There is also a steam pipe, R, provided for the purpose of cleansing the pan when necessary. When the syrnp is sufficiently boiled it is discharged throngh a valve, S, fitted to the bottom of the pan into a heater. This heater is simply a vessel usnally somewhat like the bottom half of the vacuum pan, being fitted with the steam jacket, but without the steam coil. We will now proceed to describe the method of working these pans as usually followed in the colonies :—

The cane-juice after being thoroughly clarified is evaporated in the common battery of open pans, to the density of about 27° Baume, as already described. It is then charged into cisterns, placed in a convenient part of the works, to suit the position of the pan, as few sugar plantations have facilities for keeping a vacuum pan constantly at work; in many cases with an ordinary sized pan, one, or at most two days per week, is sufficient for finishing the week's grinding. When the cisterns are full of syrnp, the pan is brought into operation, and the method of proceeding is as follows: The vacnnm pan, Fig. 3, Plate 371, and the steam engine and three vacuum pumps, Fig. 4 are connected together where the pipes are shown broken. The engine and pumps are started when a vacnum is formed in tho pan, the charging cock is then opened, the pipe of which goes into the cistern containing the syrup, which immediately rushes into the pan. When the steam worm is sufficiently covered, which is easily seen by the eye glasses, steam is let into the worm, and also, into the cast iron jacket which surrounds the lower half of the pan. The injection cock for supplying the condenser with water is opened to condense the vapour from tho pan, which is drawn off, by the three single acting air pumps worked by the engine Fig. 4. When the syrup is sufficiently concentrated to the satisfaction of the attendant, who can see through the eye glasses with the aid of a lamp at the opposite glass within the pan; the charging cock is opened, a fresh charge put in, and so on until the full charge required is obtained, which the attendant knows from time to time, with the aid of the proof stick.

When the attendant is satisfied, by the aid of the proof stick, that the reqnisite degree of concentration and granulation has taken place, the boiling is considered finished: the steam and other connections being shut off, the air plng is withdrawn, the air rushing in with a loud noise to fill up the vacuum in the pan. The concentrated syrup is then discharged from the pan throngh the valve in the bottom into the heater, (not shown in the plate) the object of which is to further develop the crystals, or grains, previous to its treatment in the centrifugal machines, shown in Figs. 7, 8 and 9.

(To be continued.)

IRON RAILWAY TURNTABLES.

The great importance of the adoption of accurate principles in designing railway turntables cannot be better attested than by the number and variety of designs which have from time to time been developed and patented, each one asserting some special snperiority over its predecessors. We propose in the present article to consider practically the duties and construction of the apparatus referred to.

Turntables are used for two purposes: to enable a carriage or engine to be transferred from one track to another, laying at an angle to the track off which snch carriage or engine is coming; and, secondly, for completely turning round such engines or carriages as are desired always to run with *their fronts foremost*—this being desirable with all locomotive engines having tenders, and with some carriages peculiarly fitted in the axle-boxes.

The requirements to be satisfied in order that a turntable may work properly aro, that it shall be steady and firm when a carriage is moving on to it, and that it shall revolve with the least possible friction; and, at the same time, the parts must be strong and durable, without sacrificing simplicity and cheapness.

It is in tho first place necessary to enumerate the principal or essential parts of which all turntables consist, after which the various modifications of detail may be more conveniently treated of in their proper places. Commencing, then, at the foundation, we have first the centre pillar and the roller path, or as it is more commonly termed, the *roller race*. These two parts maintain the whole weight of the turntable and its superincumbent load between them, in proportions dependent upon the design of the superstructure, and they are firmly secured to the masonry foundations provided to receive them. The superstructure consists mainly of the turntable proper or top provided with a centre upon which to revolve, and having underneath its periphery and resting upon them the rollers which, when the machine is in motion, travel upon the lower roller race. Upon the top of the table are fixed the rails to receive the carriages or engines which may be run npon the turntable. A vertical section of the general arrangement of a carriage turntable is shown in Fig. 1. A B re-

FIG. 1.

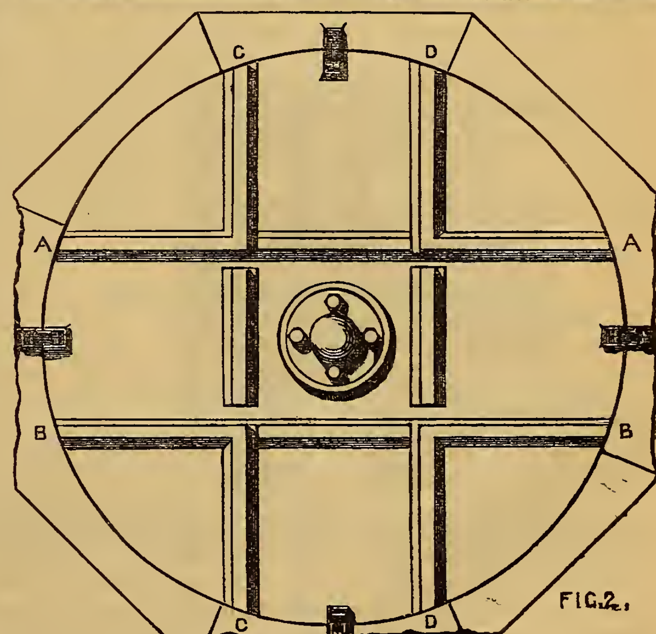


FIG. 2.

presents the table top; C the centre upon which it revolves; D is the centre pillar or pedestal carrying a cup in which the centre, C, rests and revolves; K K, which is called the jacket, surrounds the pillar, D, and is fixed to the top A B; E E shows the rails forming the lower rolling race, and F F those of the upper rolling race, being, in fact, a bearing surface fixed on the under side of the table, and resting upon the rollers, G G,

which carry the periphery of the table. These rollers are held in position by radial rods, H H, upon which they revolve, the inner extremities of these rods being carried in a loose ring, I I, free to revolve about the central pillar, D, to accommodate the travelling of the rollers round the roller race. The rollers, G G, may be supplied in any number thought convenient, according to the diameter of the turntable and the load it is intended to carry; J J is the curb. Having thus shown the general arrangement of an ordinary turntable, we can now proceed to consider the details of its construction, assuming in the first case that the load is tolerably equally divided between the peripheral rollers and the centre of the table. The arrangement of the beams or girders which compose the top or platform of the table may conveniently be referred to in the first place, together with their attachment to the jacket or centre of the machine, for usually these girders are firmly bolted or otherwise secured to the jacket, and the jacket is bolted to the cap which carries the centre proper upon which the table revolves. This centre and the cup in which it revolves should both be made of cast steel, in order to reduce the wear to a minimum, for as in the first instance the centre is supposed to rest on almost one point of contact between the centre and cup, the friction at this part will increase in proportion as the centre and cup wears together; therefore they should be made of the most durable material that can be conveniently obtained. Fig. 2 shows a plan of the turntable top, with the disposition of the rails under which the girders carrying the table should be fixed. Thus we see there will be two girders, C C, D D, crossing the table, which are intersected or cut into three pieces each by the girders A A and B B, which pass uninterruptedly across the table.

The portions of those girders, C C, D D, which are divided by the main girders, A A, B B, may be attached to the latter in any convenient way by means of brackets or angle pieces. In all cases it will be observed that the girders in this design act as beams supported at both ends, and their strength may be calculated accordingly. The jacket is usually made of cast iron, somewhat similar in form to a cross, and to this jacket the girders are bolted, as shown in the enlarged view, Fig. 3. In this

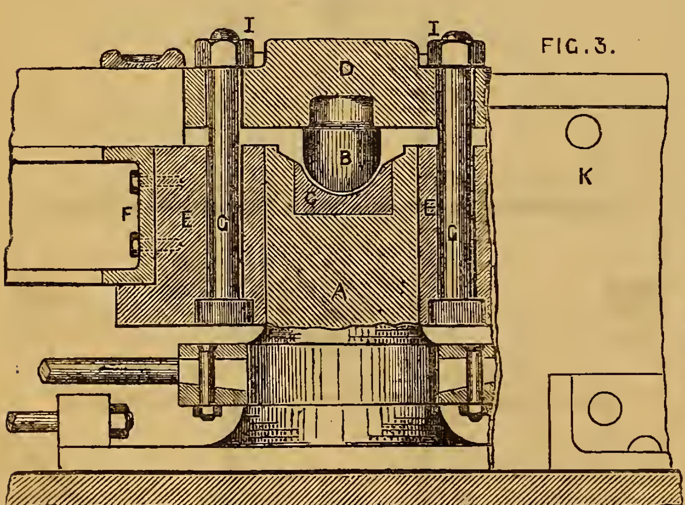
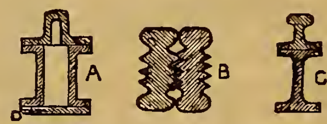


FIG. 3.

case A shows in section part of the pedestal or centre pillar; F shows in cross sections one of two main girders bolted to the jacket E E, the strain on the bolts being partly relieved by the girders resting on the projecting fillet. Through the jacket passes the bolts, G G, which may be four or more in number, according to the size of the turntable for which they are required. These are termed suspending bolts, and pass through the flange of the cap, D, being secured by the nuts, I I. Carried by its tang in a recess in the underside of the cap, is the centre, B, which rests in the cup, C, the latter being fitted into a recess in the top of the pedestal, A. From this arrangement it will be seen that by tightening or slackening the nuts, I I, the jacket, and with it the whole top or table, may be raised or lowered so as to take its proper bearing upon the rollers under its periphery. K is part of the curb. For very small turntables cast iron tops are sometimes used, but in the present article we purpose only to deal with such as are entirely or chiefly composed of wrought iron.

Stiffness being an important element in the construction of the girders, and at the same time convenience for attaching the rails, many sections have been tried, of which the following are the principal ones. One table much used has its girders formed of two channel irons, placed back to back (as at A, Fig. 4), carrying an ordinary bridge rail on the

FIG. 4.

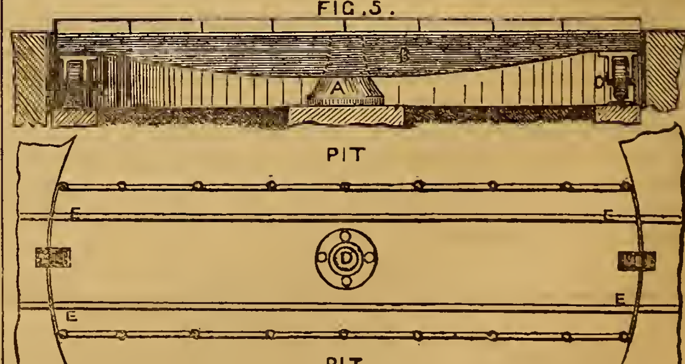


top, and being strengthened at the points of intersection by plates, D, placed beneath the joints. At B is shown another form of girder proposed, consisting of bars somewhat similar to railway iron, but much deeper, and formed with longitudinal grooves and ridges, to enable them to be fastened together. C represents a simple H iron girder, which possesses great advantages, as it exhibits great rigidity, and at the same time being simple, and requiring very little workmanship in fitting together is economical.

It has been proposed to replace the peripheral rollers under the turntable with balls or spheres running in a grooved race, but as might have been anticipated, the result was a failure; for as it would be impossible to obtain all the spheres for any particular table of exactly the same size, and to ensure their running with perfect truth in the race or channel provided for them, so it follows that within a short time the spheres overtake each other in some place or another, and so becoming jammed together require great force to move them, and the table becomes useless until it is readjusted, when the same course is again followed; hence these tables have not come into use.

In tables of the description above referred to the greater part of the load is assumed to be sustained by the rollers, and this evidently involves a great deal of friction, which by adopting a different principle may be avoided, and, indeed, is in Seller's turntable, which is almost entirely used for locomotive turntables. Its general form in elevation and plan is shown in Fig. 5. A represents the centre pillar, which is fitted at the top exactly

FIG. 5.



the same as that shown in Fig. 3; B is one of two parallel girders placed immediately under and carrying the rails upon which the engine to be turned is run. In this table there is only one track, as it is used in

cases where the engine or carriage is required to be turned end for end, or through half a circle, and they are frequently made 42ft. in diameter, and even more, according to the length of engine and tender for which they are designed to be used. C C are rollers arranged under the ends of the table upon a roller race, but they are so placed as not to touch the rails when the table is truly in balance, as the table is designed to revolve entirely upon the centre. Wherefore the rollers at the extremities are only requisite to take the weight coming on and leaving the table, as, if they were not supplied it would be upset at such times. In Plan E E, E E, are the rails resting upon the girders, and on each side is a platform guarded by a handrail, as shown in elevation, for the man to pass backwards and forwards. These tables, when accurately made, may easily be pushed round by one man with a load of forty tons on them, and without the interposition of any gearing whatever. D represents the cap over the centre upon which the table turns.

In making the flooring of turntables formerly, wood was principally used, but more recently its place is being taken in a great degree by iron chequered plates, which form a strong and durable platform. It is very undesirable to place turntables on a main line if it can be avoided, as the frequent running of trains at high speeds over them is eminently destructive to the mechanism both of the turntables and of the locomotives themselves; hence they should be placed as much as possible on sidings, and, indeed, locomotive turntables should always be put down on sidings specially provided for them. Where, however, it is unavoidable to have a turntable on a main line, care should be taken to place a sufficient number of rollers under it, in order to keep it as steady as possible under the circumstances.

OPENING OF THE SOMERSET DOCK, MALTA.

On the afternoon of the 16th February, the Somerset Dock was opened in presence of the Naval Commander-in-Chief, Vice-Admiral Sir Hastings Yelverton, K.C.B., with the Rev. Dr. Harris, Bishop of Gibraltar, and a large concourse of spectators. The last stone was lowered into its place by Miss Barbara Yelverton, daughter of the Commander-in-Chief. The gallant Admiral then stepped forward, and, announcing the dock to be complete, named it the "Somerset Dock." This being made known by a preconcerted signal, the squadron fired a salute of 21 guns. Her Majesty's ship *Caledonia* took her place in the new dock, and was taken charge of by the master shipwright, Mr. Martin. The first steps taken by the British Government for providing dock accommodation in Malta for the fleet occurred shortly after the possession of the island was secured by the Congress of Vienna, in 1814. The beginning was on a small scale; a graving dock of small dimensions was attempted on the south side of the Dockyard Creek, near Sta. Margarita-hill; but the fissures in the rock were too much for the engineers engaged upon it, and the great infiltration of water prevented its completion. The same difficulties have been met with in the "Somerset Dock;" but modern appliances were brought to bear upon it with success, and the result is one of the driest docks in existence. A second attempt was made in 1840, when the old dock was commenced by Mr. Scamp. This work was successfully completed in 1848 by Mr. John Scott Tucker. An additional length was added to it in 1857 by Mr. Churchward, who completed it as it at present exists. The following comparative dimensions show the greatly increased accommodation afforded to the Navy by the Somerset Dock:—Depth in entrance and on floor, 34ft. in the Somerset Dock, instead of 25ft., the depth in the old dock; width between copings, 104ft., instead of 82ft.; length on floor, 430ft., instead of 310ft.; width of entrance, 80ft. instead of 73ft. Thus we have 9ft. additional depth of water, 22ft. increased width, 120ft. increased length, and 7ft. greater width of entrance. In respect of cost the Somerset Dock will compare very favourably with the old dock. The cost of the latter was £60,000, and it was afterwards lengthened at an additional cost of £90,000. This gives a total of £150,000, which is about the same as the Somerset Dock, excluding the extra work in clearing the rock overlying the site and the wharves adjoining thereto, which did not occur at the old dock. The cost of the Somerset Dock is swelled considerably, in consequence of the great expense incurred in making the entrance to it, which is equal to a dock in itself of 270ft. in length, 83ft. wide, and 34ft. deep. No such additional work was necessary in forming the old dock, as it was merely an extension of the creek.

THE STRAINS OF SHIPS AT SEA.

A paper embodying an investigation of the strains which ships undergo at sea was read on February 9th, at the Royal Society, by Mr. E. J. Reed, C.B., late Chief Constructor of the Navy. The author, after pointing out that little or no practical progress had been made on this subject since the early part of the present century, proceeded to state that the introduction of steam navigation and of iron and steel as shipbuilding materials had rendered a thorough examination of it extremely necessary, and that he had consequently selected four ships, as types of the various descriptions of modern vessels—viz., Her Majesty's yacht *Victoria and Albert*, as a type of long, fine-lined, lightly-built ships, with great weight of engines and boilers in the middle; the *Minotaur*, as a type of long, fine-lined ships, with great weights distributed along their entire length; the *Bellerophon*, as a representative of short, stoutly-built ships, with weights more concentrated; and the *Audacious*, as a model of ships with extremely concentrated weights. The smooth water strains of all these ships were illustrated by numerous diagrams embodying the results of various calculations, and the effects of placing such ships among waves were then no less fully investigated. The great bulk of the paper consisted of detailed calculations too long to insert, but some of the facts and figures deduced were very striking. It was shown, for example, that a ship like the *Minotaur*, floating among waves 400ft. long and 25ft. high from hollow to crest, which have a time of transit of about $8\frac{3}{4}$ seconds, passed in half that time from a bending or breaking "moment" of 140,000 foot-tons tending to break her in two by the drooping of the ends to a reverse strain of 74,000 foot-tons, so that 15 times per minute a "wave of strain," as Mr. Reed designated it, having these enormous quantities for its positive and negative amounts, sweeps through the fabric of her hull. The *Victoria and Albert* yacht has to undergo, in like manner, strains which tend to break her downwards at the ends with a force of 16,400 foot-tons, and in less than four seconds encounters a strain tending to break her downwards at the middle, and let her engines and boilers fall through her, equal to nearly double this amount, or 31,000 foot-tons. It is remarkable that this change of strain in this lightly-built hull is proportionately greater than that of either of the ironclads. The *Bellerophon's* maximum strains in waves, similarly calculated, were 43,600 foot-tons and 48,800 foot-tons respectively. In illustrating the influence which rapid changes of strain exert upon structures, the author referred to the experiments of Sir W. Fairbairn, who has shown that the joints of an iron-riveted beam broke under the action of a rapidly-alternating strain, although it was only one-third in amount of what the beam would sustain at rest. Mr. Reed stated that his investigations had shown many of the general principles laid down by former investigators, who had dealt with very different forms of ships, to be erroneous, and, in particular, opposed the very common notion that there is a compensating action between the strains of, and the wave actions exerted upon, very long fine-lined vessels. He further stated that while the weakness exhibited by many modern ships had induced him to enter upon these investigations, the result of them had been to convince him that calculations which had hitherto been neglected were becoming daily more and more necessary, especially as the length of steamships and the lightness of their construction in iron and steel were being very rapidly and simultaneously developed.

ROYAL NATIONAL LIFEBOAT INSTITUTION.

On the 2nd ult. a meeting of this institution was held at its house, John-street, Adelphi, Mr. Thomas Chapman, F.R.S., vice-president, in the chair. The minutes of the previous meeting having been read, the silver medal of the institution and a copy of its vote inscribed on vellum were ordered to be presented to Mr. Paul Curnow, the coxswain of the *Covent-garden* lifeboat at St. Ives, Cornwall, together with £12 10s. to himself and the crew of the boat, in testimony of their recent gallant services in saving the crew of six men from the brigantine *Queen*, of Youghal, which stranded on Carrack Gladden beach during a heavy north-west gale. Rewards amounting to £460 were also voted to the crews of various lifeboats of the institution for going off on service during the storms of the past month. The Mincing-lane lifeboat, at Montrose, went out throught a very heavy sea, and with much difficulty took off the crew of five men of the distressed Danish schooner *Dania*. The Dungarvan lifeboat was also the means of saving 20 persons from the brigantine *Margaret*, of Lancaster, which had gone ashore off Dungarvan during a strong gale and in a heavy sea. The lifeboat at Hornsea rescued from the stranded bark *Martha*, of Arendal, Norway, 15 persons, who were in imminent peril. The Bridlington large lifeboat was the means, during a fearful gale, of saving the crews, numbering 16 men, of the wrecked bark *Friend's Increase*, of London; brigantine *Echo*, of Maldon; of Maldon; and the brig *Windsor*, of Lynn. The Ramsey lifeboat most gallantly succeeded, after many hours' exertion,

in getting safely into harbour the schooner *William*, of Liverpool, and her crew, that vessel having been in distress near the Point of Ayre. The Holyhead lifeboat was likewise instrumental, with some difficulty, in saving the crew of the steamer *Alexandra*, of London, which had gone on the Clipera Rocks. The Pakefield large lifeboat was the means of saving the distressed schooner *Frances*, of Cardigan, and her crew of four men. The Margate lifeboat went off during very dark and cold weather, and saved the crew of nine men from the brig *Thessalia*, of Whitby, which had stranded on the rocks off Margate during a strong gale and in a very heavy sea, on the 10th of February. On the same and following days the Kingsdowne, Filey, Tynemouth, and Hasborough lifeboats were severally the means of saving altogether 40 men from the bark *Richard* and *Harriet*, of Hull; the schooner *Mary*, of North Shields; the brig *British Queen*, of London; the brig *Valiant*, of Jersey; and the barks *Launceston*, of Shields, and *Arctic Hero*, of Goole. On the 12th of February the Tramore lifeboat went off to the schooner *Stranger*, of Newfoundland, which became a total wreck; fortunately the lifeboat was able to save the crew of three men. The Bull Bay lifeboat took into harbour the schooner *Albion*, of Beaumaris, and her crew. The Newcastle (Dundrum) lifeboat saved the crow of five men from the brigantine *William*, of Londonderry, which soon afterwards became a total wreck. The Port Madoc lifeboat rendered good service to the ship *River Nith*, of Liverpool, which had gone ashore off that lifeboat station. The Fisguard No. 1 lifeboat brought ashore the crews, consisting of ten men, of the schooner *Halswell*, of Bridgewater, and *J.W.A.*, of Newquay. The Wicklow lifeboat was able to render most important aid to the disabled brigantine *Pomona*, of Dundalk, which, with her crew, was taken safely to Dublin; and the Caister large lifeboat landed the crew of 13 men of the bark *Jane Kilgour*, of London, which became a total wreck on the Cross Sand off the Norfolk coast. Various other rewards were likewise granted to the crews of shore boats for saving life from wrecks on our coasts. The institution during the storms of the past two months contributed to the saving of 406 lives, and in the same period has given rewards to the amount of £1,022 to the crews of its lifeboats and others for noble deeds.

A SINGLE-RAIL TRAMWAY.

In thinly-peopled and mountainous countries, and especially in many parts of Turkey, the want of roads for internal communication is the great difficulty in the way of national progress. It is also a difficulty well-nigh insurmountable by the methods to which we are accustomed in the more favoured parts of Europe, because there is no capital available for the purpose of making communications that would have to create their own traffic, and that would probably ruin the owners before they had done so. For example, about ten years ago, a road was made from Beyrouth to Damascus, and upon this there is not only not a single native waggon running, but the muleteers and camel drivers take the old breakneck track by choice, because it is shorter from point to point, and is free from the trifling toll which is charged on the highway. Moreover, in such countries the value of an ordinary road is much diminished by the inevitable steepness of the gradients, which render it necessary that a waggon should carry but a small load. A carriage road is now being constructed, at a vast expense, between Alexandretta and Aleppo; and seems likely to be as little traversed as that to Damascus. It is being carried through the pass of Beilan; and, in order to obtain even tolerable inclines, a distance which is only 70 miles by mule tract will be increased to more than 100 by the new road. Mule and camel drivers will certainly not use it, more especially as it is badly supplied with water; and as the steepest gradient will be one in $7\frac{3}{4}$, it is difficult to conceive that wheel traffic can ever become a source of profit. A railway on the European system would be simply impracticable. Water and fuel are scarce, skilled labour is expensive and would have to be imported, the country is very difficult, and the whole value of the transport to and fro is now about £62,000 a year. At £10,000 a mile the cost of constructing a railway would be a million sterling; and, when working expenses were paid, little would remain for the shareholders. Such a line may possibly be needed hereafter as a portion of a route to India, through Alexandretta and Aleppo, to the Euphrates, and thence to Bagdad, and, as it would pass through a fine grain country, it may eventually be in itself profitable. The present need, however, is to provide a means of traffic not much in excess of the actual or probable demand, and suited to the wants of a country in which railroads are impossible from their cost, in which roads are useless because the natives find that carriages do not pay, and in which there can be no canals because water will not run up hill. In the face of these conditions Mr. J. L. Haddan, C.E., has devised a single-rail tramway for conveyances, of which he gives the following description:—

"Imagine a bicycle let into a longitudinal aperture in the centre of the bottom of a cart, and the cart nearly touching the ground, so that only about six inches of the wheels would be visible; next, a kind of balancing pole run through the sides of the cart at right angles to the single rail on which the bicycle is to run. The two ends of the pole are to project about three feet on either side of the cart, and rest upon, and be harnessed to, the backs of two mules. The animals will thus be one at each side of the load, instead of being in front in the ordinary way. It would be impossible for the cart to turn over, because, in order to do so, it would have to force one mule to the ground and to lift the other into the air; and, moreover, as its floor would only be six inches above the rail, an overtip would be of no account. All the weight in the cart, if evenly distributed, would bear upon the rail, and the animals, having no load on their backs, would be able to exert considerable traction power."

Mr. Haddan thinks it an incidental advantage that with such a tramway the muleteers would be compelled to keep the appointed way, instead of leaving it, as they now do, by side tracks that enable them to avoid toll bars; but, at the same time, he proposes to give the wheels broad double flanges, so that in case of need the carts would run upon any good road. He states that responsible contractors are prepared to lay his single line, with 30lb. rails and De Bergue's pot sleepers, at a cost of £450 per mile, all sidings included.

Mr. Haddan does not consider that the utility of his invention will be limited by the precise conditions that first called for it. He not only suggests its employment for military purposes, but also for tramways in large cities; and he says that, where space is very valuable, a horse or mule on only one side of the cart would be sufficient. In towns, on bridges and other important places, the rail might for a short distance be dispensed with; and passenger vehicles should be fitted with small friction wheels on either side, so that, if a horse should fall down, the balance of the carriage would remain undisturbed.

DEEP SEA EXPLORATIONS.

On the 10th ult at the Royal Institution, Dr. W. B. Carpenter, V.P.R.S., &c., delivered a lecture descriptive of the results of the expedition undertaken last autumn in Her Majesty's ship *Porcupine*, for the purpose of deep sea dredging and other explorations in the Mediterranean and in the Straits of Gibraltar. The results obtained in the expedition of 1869 were so important that the Council of the Royal Society urged upon the Government the advantage of continuing the investigations over a different area, and hence the *Porcupine*, still, as before, under the command of Captain Calver, R.N., was again placed at the disposal of the explorers. The work of the expedition was divided into two cruises—the first to examine the deep sea bottom between Falmouth and Gibraltar; the second to make the like examination of the western basin of the Mediterranean between Gibraltar and Malta, and to determine its physical and biological relations to the Atlantic, with special reference to the Mediterranean current. The first cruise was under the direction of Mr. Gwyn Jefferies, assisted by Mr. Lindahl, of Lund, and Mr. W. L. Carpenter; the second under that of Dr. Carpenter, assisted by Mr. Lindahl and Mr. P. H. Carpenter. Professor Wyville Thompson was to have taken part in this expedition, but was prevented doing so by illness.

Dr. Carpenter's lecture was confined to an account of some of the results of the second cruise, and he first spoke of the barronness of the Mediterranean bottom in respect of animal life. He then proceeded to describe the general formation of the sea bed in the parts visited, and exhibited diagrams of the narrow portion of the Straits of Gibraltar, and diagrammatic sections, first of the length of the Mediterranean from Gibraltar through Malta to Egypt, next of the Straits from Cape Trafalgar to Cape Spartel, from Europa Point to Apes Hill, and again, longitudinally, from one of the foregoing sections to the other. These sections showed that although the Mediterranean is generally nearly 2,000 fathoms in depth, it is divided by a ridge, of which the island of Malta forms part, into an eastern and a western basin, and that its depths are cut off from those of the Atlantic at the Straits, where the bottom is nowhere deeper than about 200 fathoms. The temperature of the Mediterranean is altogether exceptional, for whereas that of the North Sea and the Atlantic steadily descends and approaches the freezing point at about 2,000 fathoms, the general deep sea temperature of the Mediterranean does not fall below about 55 deg., which is attained at about 100 fathoms. The cause of this was explained to be that the surface water, heated by the sun, was also concentrated by evaporation, and thus being rendered at once hotter and heavier than the strata below, sank down, carrying its heat with it. Without some compensating influence the continued action thus produced would tend to a regular and steady increase in the degree of saltness of the water, especially as the rate of evaporation is in excess of the supply brought in by rain and rivers, and therefore leads to a steady surface current inwards from the Atlantic. The lecturer showed, however, that beneath this surface

current there would be another in an opposite direction. A given column of Mediterranean water, concentrated by evaporation, and with its loss in point of quantity made good by the Atlantic would be heavier than a column of Atlantic water of the same dimensions, and would displace the latter by pressure. The existence and direction of the deep outward current thus produced had been experimentally determined by an ingenious current-drag, contrived by Captain Calver; and the demonstration was on the whole complete; that the sinking water, concentrated by evaporation, was thus so borne outwards through the Straits that the concentration had no tendency to exceed a certain degree. The Mediterranean received from its river feeders, especially from the Rhone, a vast amount of mud in a state of very fine division; and Dr. Carpenter found the turbidity of the deeper strata to be very marked, and to be due to the presence of particles so small that they could scarcely be removed by filtration. He believed these particles were the cause of the absence of animal life at great depth, and that they would act by mechanically clogging the gills or other respiratory membranes of any deep sea fauna. He referred to Professor Tyndall's electric light test of the presence of fine particles, both in the water of the Mediterranean and in that of the Lake of Geneva, and quoted a marine engineer to the effect that the incrustation formed in boilers used in the Mediterranean, consisted not only of salt, but also of very finely divided mud. Geologists were aware of the scarcity of fossils in strata that had been formed by the deposition of extremely minute partioles.

LAUNCH OF H.M.S. "GLATTON."

On the 8th ult., the armour turret-ship *Glatton* was floated out of dock at Chatham in the presence of an unusually-large concourse of spectators. The building of this ship was commenced in the latter part of 1868, and she was floated out with the whole of her armour-plating bolted to her sides, and, excepting the finishing of her internal fittings, and the completion of some other trifling work, ready to receive her officers and crew, and proceed to sea.

The *Glatton* has been designed as the first of an unusually powerful squadron of ironclads, of comparatively small draught of water, for channel service and the defence of our shores.

Her leading dimensions are as follows: Length between the perpendiculars, 245ft.; do. over all, 263½ft.; extreme breadth, 54ft.; depth of hold, 19ft. 4in.; draught of water, 19ft.; do. in fighting trim, 20ft.; burthen, in tons, 2,709,4-94.

She is armoured along her whole length with two strakes of plates, each 3ft. wide, the upper 12in., the lower 10in. thick; the thicknesses being the same for the entire length of the belt, saving two plates in each strake at each end of the ship, where a slight diminishment is made to 10in. aud 8in. Upon the deck is raised a heavily-armoured oval fort or chamber, carrying atop at the forward end a massive armoured turret for the two 600-pounder 25-ton guns. The sides or "breastwork" of this deck-chamber are about 9½ft. high and plated over their whole extent with 12in. armour. The turret is plated over and around the gun ports with armour 14in. thick, and over the remainder of its circumference with 12in. of solid iron. Her bunkers provide stowage for 240 tons of coals; but by using her water-ballast bunks she will be enabled to carry 500 tons, but in that case her deck would only be about 18in. above the water. Her engines, made by Messrs. Laird on the horizontal trunk system, and which are already in the vessel are 500-horse power nominal. These are estimated to work up to 3,000 indicated horse power, giving a theoretical speed of nearly 10 knots (9¾), the area of midship section being 910½ square feet. The propulsion is by double screws of four blades. The depth of the hold is 19ft. 4in., aud the spaces not occupied by the engines and boilers are fitted up for officers and crew (200 men). The air is pumped down when at sea and in action; but otherwise, when in harbour or in fine weather, it can descend through scuttles, which are armoured with 10in. iron for 3ft. 6in. above the deck. The armour of the hull is not made flush with the ship's side as has heretofore universally been the case, but it is carried on a square overhanging bracket-shelf projecting, with the 20in. of wood backing behind the armour, to a distance of 2ft. 6in. from the external skin of the hull. Like all the late chief constructor's ships, this hull has a double bottom and sides, the distance between the skins being 2ft. beneath and thence tapering to 4ft. atop of the sides at the level of armour bracket. There are girders and bulkheads dividing the double-skin spaces into water-tight compartments, and giving passages on each side of the vessel. There is another innovation, in the plating of the deck, which is of 3in. of iron, covered by 6in. of oak planking. This deck plating is continued beyond the skin of the ship and the wood backing up to the top of the armour itself, to which it is rivetted. The turret is 31ft. in external diameter, and will train by rack and pinion gear; the armour of the hull has a backing of 17in. of oak behind the 12in. plates, and of 15in. behind the 14in plates. The backing of the 12in. plating of the breastwork is 18in. of oak. The armour of the turrets is secured by Lieutenant English's costly bolts. The space around the base of the turret is covered with glacis plates, 3ft. 6in. wide and 3in. thick, for a distance of 8in., thence tapering away gradually to 1½in. thick at the margins. The plates, of 14in. and 12in. thick, were, as well as the tubular combings, all rolled at the works of Messrs. Cammell, of Sheffield. A portion of the 10in. plates were rolled by Sir John Brown and Co. The glacis plates were made at the Thames Iron Works. The total weight of armour-plating protecting the sides, breastwork, and turret of the *Glatton* is 1,190 tons, of a minimum thickness of 10in. When going into action the space between her inner and outer bottom will be filled with water to increase her submersion.

The arrangements connected with the launch were of a very simple character. The ceremony of "christening" the *Glatton* was performed by Miss Scott, daughter of the Very Rev. Dr. Scott, Dean of Rochester. A bottle of wine having been dashed against the bows of the *Glatton*, she was slowly hauled out of the dock by means of a couple of steamers, and safely placed at her moorings in the harbour, the spectators present giving several hearty cheers, and the bands playing "Rule Britannia."

ON STEAM BOILER EXPLOSIONS.

We have been requested to insert the following memorial:—

To John Hick, Esq., M.P., chairman of the Select Committee of the House of Commons on steam boiler explosions.

Sir,—Allow me, as President of the Liverpool Polytechnic Society, to express to you the warm sympathy our society feels with the inquiry your honourable committee has undertaken with regard to "the cause of steam boiler explosions, and the best means of preventing them." Such an inquiry we consider to be called for, both in the behalf of science and humanity—seeing the constant recurrence of steam boiler explosions—and the long train of suffering entailed by them year after year. Our attention has been more specially drawn to this subject by the occurrence of a fatal explosion in this town, since your committee closed its labours at the end of last session; and our society having taken the subject of steam boiler legislation into consideration, we venture to forward you the conclusions to which we have been led, and shall be happy if this communication prove of any assistance to you in conducting the important inquiry your honourable committee has undertaken. As the catastrophe just referred to was of a very suggestive character, we may commence by making brief reference to it. This explosion occurred on the 4th of October last, at a small iron foundry in Brunswick-road, Liverpool, which is a populous part of the town. The boiler from which the explosion sprung was a very small one, being only 3ft. 4in. in diameter, by 6ft. 4in. long; so that it might have been regarded by many as incapable of doing much mischief. The view, however, that small boilers can do comparatively little damage is quite erroneous. When the boiler burst, it laid the foundry in ruins, and levelled the wall dividing the works from the public thoroughfare, scattering the *débris* right and left, and so damaging the surrounding houses that they presented the appearance of having been bombarded. Added to this, four persons were killed, as well as four injured. Of the four persons killed, one was a lad attending the boiler, quite incompetent, from his youth and inexperience, to understand the danger to which his life was exposed. Two others were children in a dwelling-house on the opposite side of the street to which the explosion occurred, while the fourth was another child on the public highway. The owners of the boiler were working-men, who had recently started the foundry, and possessed but little or no capital. By the destruction of their works, they were ruined, so that they were totally unable to make any compensation for the injuries either to property, life, or limb, which they had occasioned.

The little boiler from which all this devastation sprung was an old one. It was second-hand, and had seen considerable service when laid down. At the time of its explosion, it was thoroughly worn out, the plates being eaten away in places till reduced to the thickness of about $\frac{1}{16}$th of an inch. Had this boiler been inspected by competent parties, the danger must have been seen in time to prevent the explosion, and thus have saved the four lives which were sacrificed. Here, then, was an old, worn out boiler allowed to be set down in a populous part of the town, surrounded by dwelling-houses, and only cut off from a public thoroughfare by a wall affording concealment but no defence. It was worked on in apparent security till explosion occurred, killing some and injuring others, in the adjacent dwelling-houses, and on the public highway, as well as doing considerable mischief to property, while the owners, from their poverty, were unable to repair or compensate the injuries they had caused. As there are many steam boilers in all large towns and cities, working under very similar circumstances to those described above, whereby the lives of persons living near them are jeopardised, though they have no share whatever in the management of

the boilers, we cannot but think that the time has arrived when the Government should interfere in the behalf of public safety, by forbidding any boiler to be worked unless periodically examined by duly authorised parties, and certified at least once a year as safe and trustworthy. Having had this view impressed upon us, we have taken into consideration the way in which such a system of inspection could be best carried out in the interest of all parties concerned, and the following are the conclusions to which we have arrived:—We are aware that Mr. Sheridan, M.P. for Dudley, has obtained leave to bring in a bill for submitting all the boilers in the country to the supervision of the Board of Trade. This proposition our society cannot regard with favour. The science of boiler engineering is one that is rapidly developing. Pressures are being increased, thus necessitating changes in construction, while changes are also being made in the material employed. The whole matter is in a state of growth. It is feared, therefore, that any Governmental system of inspection would be found too rigid to accommodate itself to the varying requirements of this healthy progress, which it is so important not to hinder, and that such a system would consequently prove a drag upon commercial and engineering skill. We have also considered the proposition that the inspection should be undertaken by the municipal and other local authorities, but we fear that in such a system there would be a great want of unity, and, consequently, of harmonious action; serious complications would arise from this, and it would not be adequate to the production of an efficient system of inspection. We have further considered the proposition that Government should simply pass a law compelling every boiler to be placed under inspection, leaving it to private individuals, to companies, or to associations, to make the inspections, and grant the certificates. We cannot consider that such a system as this would secure the competency of the inspection, or that the execution of duties so important for the public safety as the inspection of boilers should be entrusted to private competing parties, undertaking them for profit. We have been the more impressed with this view, and that the inspection should be responsible, by a circumstance attendant on the explosion to which reference has been already made. The boiler in question, though so old and decrepit, had been examined by a fitter only six months before the explosion occurred, and pronounced by him as safe and sound; indeed, so much so that this unauthorised inspector said it would last the owners' lifetime. Yet, shortly after this, it burst, with the serious consequences already described. At the coroner's inquest the owners were committed for manslaughter, and took their trial at the Liverpool Winter Assizes, when the judge ruled that, inasmuch as the prisoners had caused the boiler to be inspected, they had deputed their responsibility, freed themselves from blame, and, thus, must be acquitted. We would venture strongly to urge the consideration of this trial upon your honourable committee, and would beg to point out how fatal it would be to a measure for the prevention of boiler explosions, if owners might exonerate themselves from blame, simply by purchasing a certificate from irresponsible parties. Such a measure might be productive of profit to those who might grant the certificates, but not of safety to the public. Another plan which has been proposed is, that while the Government should enforce inspection, it should not undertake that duty itself, but entrust it to certain authorised boards, appointed by the steam users themselves, who practically represent the public. On this plan the country would be mapped out into a given number of districts, with one board appointed to each. Thus, the entire country would be covered, and the boards, though each working in its own district, would form together a national series, and one complete whole. To promote unity in these boards, it is proposed that an annual conference should be held, composed of deputies from each district. This plan we consider more likely to meet the requirements of the case than any other which has come under our notice. The inspection would be enforced by the Government to ensure its adoption, but it would be administered by the steam users, which, we think, would be more generally acceptable; while, from the district boards being linked together into one national system, contradictions would be avoided, and, from the work being undertaken not for profit but in discharge of a public duty, the purity of the inspection would be secured. It also appears to us that such an organisation might become the means of diffusing among steam users themselves much valuable information, and in this way such a system as we have sketched out would become a help, rather than a hindrance, to engineering and commercial progress. The above are the conclusions to which we have been led by the consideration we have given to this subject, and we shall be glad if, by communicating them to you, we are able to render any service to this most important inquiry your honourable committee has undertaken. Trusting that the labours of your committee may result in the framing of some measure that will prove successful in preventing the present great sacrifice of life from boiler explosions, but which shall not, as a consequence, entail upon the use of steam power unnecessary and vexations restrictions.

(Signed) Antony Bower, President. James N. Shoolbred, Sec.

IMPROVED PROCESS OF EXTRACTING SILVER AND GOLD FROM ARSENIO-SULPHURETS OF LEAD, COPPER, &c.

By C. Widemann.

This very interesting and entirely new process was discovered by Cyprien Marie Tessié du Motay, of Paris, and is already practised on a large scale at the metallurgic establishment of Commnies. The process consists in the following series of docimastic treatments of the simple sulphurets, the complex sulphurets, and the arsenious sulphurets of lead, antimony, copper, and iron, as well as coppery matts and coppers containing precious metals, in order to extract silver and gold therefrom at a great saving in time and labour.

First. In roasting the simple or complex sulphurets, the antimonial sulphurets, and the arsenio-sulphurets containing silver or gold, in the presence of pure silicates, of auriferous quartz or earthy and metallic silicates, adding, in order to complete this roasting and to expel all the sulphur contained in the minerals, either lead, which is intended to form oxide of lead, or litharge, or any other metallic oxide capable of producing, in contact with air or oxidising flames, peroxides or silicates of peroxides.

Second. In thus transforming into the state of very fusible basic silicates, the oxides of the desulphuretted metals.

Third. In melting or running in the melted state the silicates of this kind produced upon a matt of lead also melted, and in stirring or agitating them, either by paddles held in the hand or by mechanical means, or by means of gases mechanically employed, up to the moment when the gold and silver are entirely dissolved in the melted lead.

Fourth. In separating the poor scoria deprived of the precious metals of the lead, which has taken them up, and in stiring or agitating upon the same mass of lead a fresh quantity of rich scoria.

Fifth. In repeating this liquation an indefinite number of times, until the moment when the capacity of saturation of the lead for the precious metals, which is lessened by each operation, no longer permits the continuance of this mode of treatment.

Sixth. In testing the lead saturated with silver or gold, by the methods of cupellation now in use, in order to extract therefrom the precious metals.

Seventh. In removing the poor scoria, the oxides of lead, antimony, and copper, which, for the most part, are contained therein, by bringing back these oxides to the metallic state by the separate or united action of charcoal and iron.

Eighth. In separating, by the special methods presently described, the copper and antimony from the lead with which they are united.

Ninth. In re-employing, either wholly or partly, the purified lead in the treatment, by oxidation and silication, of fresh quantities of minerals.

Tenth. In reducing, either in reverberatory or cupola furnaces, or in all other melting furnaces, the basic silicates enumerated above by the action of charcoal or iron, when the latter are the produce of minerals containing copper pyrites in considerable quantities.

The metallic matter thus obtained consists of an alloy of copper, lead, silver, and gold, free from sulphur, which may be all treated at once, either by docimastic methods in countries rich in combustibles, or by the humid process in countries where mineral acids are low in price. Having thus stated, in a general manner, M. du Motay's docimastic method, let us describe the new operations and reactions whereby they are essentially distinguished from those at present employed for the same object. These operations and reactions consist, in the first place, of the roasting, the oxidation, and the scorification of the simple or complex sulphurets of antimonio-sulphurets and arsenio-sulphurets in the presence of silica and oxides of lead, or of all other metallic oxides capable of passing into the state of peroxides or of silicate of peroxides in the oxidising flames, in order—

1. To prevent the formation of the oxysulphurets of lead, antimony, and copper, which afterward, in dissolving with the silver or gold in the lead, cause the loss, during the cupellation of an appreciable quantity of the precious metals, which are dissolved in this lead, and render inapplicable for industrial purposes either the cupellated litharges or the lead proceeding by reduction from the said litharges.

2. To prevent the complete dissolution in the lead of the silver and gold contained in the basic silicates free from sulphur, without the antimony or copper, which have passed from the state of sulphurets into the state of silicates, being able to dissolve in the lead, and consequently to injure it.

3. To obtain as the final result of a series of liquations, a testable (cupellable) lead, rich in precious metals.

4. To avoid a great number of cupellations, to obtain pure litharges transformable into lead of an equal purity, and to thus diminish the net cost of the industrial extraction of silver and gold, by means of the cupola, to a considerable extent.

The operations and reactions, in the second plaoe, consist in the reduction to pure lead, or into an alloy of lead and antimony, and copper of the scoria deprived of gold or silver, in order—

1. If the extracted lead is pure, to make it again serve by way of roasting, for the oxidation of a fresh supply of snlphuretted, arsenio-sulphuretted, or antimonio-sulphuretted minerals.

2. If the lead is alloyed with antimony or copper, or with both these metals, to separate it from one of these metals or both together, in order also to use it again, after purification, for the oxidation of a fresh qnantity of snlphurctted, arsenio-sulphuretted, or antimonio-sulphuretted minerals.

The method for separating the lead from the antimony, or from the antimony and copper nnited, constitutes one of the greatest novelties and one of the most essential parts of the invention ; taking, for example, an alloy of the lead and antimony, the inventor submits it. after having melted it in a reverberatory or a cnpola furnace to the action of the nascent steam produced by aërohydric or oxyhydric blowpipes, fed by a mixture in definite proportions of air, or of oxygen and pure hydrogen, or carbonated hydrogen. The flame procnred by these blowpipes should be as free as possible from any trace of uncombined oxygen. It is even preferred, in order to prevent any oxidation of the lead, that the flame shonld contain a little hydrogen or free carbon. The nascent steam may, perhaps, be mixed with the ordinary steam generated at 212° Fahrenheit. The antimony, which decomposes water at a high temperature, oxidises in passing into the state of antimoniate of oxide of antimony, one portion of which volatilizes while the other remains attached to the inner sides of the reverberatory or other furnace, in this operation, during which almost the whole of the antimony is separated, and the lead, which does not decompose water, is but little, or not at all oxidised, but still retains traces of antimony with a strong affinitive force, and in order to entirely purge it from this metal, it is necessary to have recourse to sulphate of lead. This new reactive has the property of becoming decomposed in oxide of lead, into free oxygen, and into sulphurous acid by antimony, which, by this decomposition, taking up the oxygen set at liberty, oxidises and combines with the oxide of lead of the decomposed snlphate. The lead is then completely purified and rendered applicable for all industrial purposes. It follows, as a matter of course, that the snlphate of lead can, by itself, withont the previous employment of steam in the nascent state separate the whole of the antimony contained in au alloy of this metal with the lead, but, in many cases, to employ it would cost too much. Earthy hydrates, such as hydrates of lime and baryta, can also be effectnally employed instead of steam in a nascent state, or ordinary steam from water, in order to oxidise the antimony and to separate it from the lead; bnt the inventor prefers the steam generated by aërohydric or oxyhydric blowpipes, which furnish at the same time the heat necessary for the fusion of the alloys and the reactive, which partly or wholly removes from the lead the antimony which injures it. When the lead is alloyed with copper, and this alloy does not contain antimony, it is melted with a quantity of sulphuret of lead rather more than equivaleut to the quantity of copper, to transform into sulphuret; this fusion is conducted away from any oxidising action iu a reducing medium, and produces an immediate reaction by way of double exchange. The sulphur combined with the lead acts npon the copper of the alloy, and thns substitutes metallic lead for the copper, which scorifies and passes into the state of sulphnret. The lead thus deprived of copper, is pure and proper to be employed, as indicated above, either for the oxidation of fresh mineral, or it may be sold for general purposes. Alkaline and alkaline earths, bisulphnrets, and polysnlphurets, as well as metallic sesqnisnlphurets and bisulphurets, may be substitnted for the sulphnret of lead, in order to remove the copper from the lead by cansing the latter metal to pass into the state of sulphuret. The sulphuret of copper may, after roasting, be transformed into metallic copper by the reducing process at present employed. When antimonio-sulphuretted argentiferous leads have been previously brought to the metallic state by the method of rednction at present employed, the inventor snbmits them to the action of the same blowpipes, and when the antimony, which has passed iuto the state of oxide, has been separated from the lead, in which the silver remains entirely dissolved, this lead is tested or cupellated, and the precious metal extracted therefrom. The chief points of novelty in this invention may be stated as follows :—

1. The method of roasting and the silicatisation of the metallic, simple, or complex sulphurets, arsenio-sulphurets, and antimonio-sulphurets containing silver or gold, by means of the processes above described.

2. The method of liquatiou and fusion by sncceesive series of argentiferous and auriferous silicates upon the same bath of lead, which deargentises and deanrifies them, by which method the same object is obtained by one cnpellation which according to the best methods at present in use requires several.

3. The method by which, after the oxides of lead, antimony, or copper contained in the silicatcs deprived of silver and gold have been brought back to tho metallic state, the lead is separated from the copper with which it is united by the addition of an equivalent quantity of sulphnret of lead, or of one of the sulphurets enumerated above, and the antimony, by the action of the aërohydric or oxyhydric blowpipes, combiued with the reaction produced by a small amount of sulphuret of lead.

4. The application of the above-described methods to the entire or partial treatment of copper matts and argentiferons and anriferous coppers of the minerals of antimoniferous lead, and of the mineral of antimony containing silver and lead or pure silver.

THE LONDON ASSOCIATION OF FOREMEN ENGINEERS.

THE ANNIVERSARY FESTIVAL.

The eighteenth anniversary festival of this institution was held on Saturday, the 25th February, at the City Terminus Hotel. The guests numbered nearly 250, and among them were representatives of every class of the engineering community—employers, managers, draughtsmen, foremen and workmen, in addition to many gentlemen of scientific celebrity.

Amongst the visitors present were E. J. Reed, Esq., C.B., (Chairman ;) and E. R. Allfrey, Esq., C.E., (Depnty-Chairman.) Supporting those gentlemen were John Hick, Esq., M.P., Rear-Admiral Inglefield, C.B., F.R.S., Capt. Donnelly, R.E., H. Wollaston Blake, Esq. M.A., F.R.S., Alfred Blyth, Esq., C.E., George Mecdonald, Esq., LL.D., Rev. Joseph Woolley, LL.D., John Penn, jun., Esq., C.E., H. Gardner, Esq., C.E., R. S. Fraser, Esq., C.E., Mr. J. Newton (president of the association), A. Dndgeon, Esq., C.E., J. H. Brinjes, Esq., C.E., S. Worssam, Esq., C.E., and others. Domestic affliction detained Colonel Hughes at home, and Sir J. Whitworth and Sir W. G. Armstrong sent letters of apology for non-attendance.

After the usual National toasts the Chairman gave "The Army, Navy, and Volunteers," and observed that it would be a very improper thing to enter on that occasion into any one of the subjects which were under consideration just now in connection with these great services, but perhaps it might not be amiss to say—and he certainly could say it with the greatest confidence, looking at the representatives of the army present—that the most urgent necessity for all of the services was extended education from top to bottom. There could be no doubt, whatever the natnral qnalities of the German troops might be, that those natural qualities of the German troops might be, that those natural were supplemented by the most perfect education that conld be given to the army, from the commander-in-chief down to the private soldier; and it could not be doubted, he thought, that in this country we should superadd to the undoubted conrage and endurance of our troops and our people all the advantages which education conld afford them ; so that they might not only know how to stand firm in the fight, but also how to fight the most effectually while standing in it. He was able to refer to this aspect of the question becanse the names of the gentlemen who would be associated with the toast were representatives of the highest education of the services—Capt. Donnelly and Rear Admiral Inglefield.

Capt. Donnelly, in responding, said he was afraid that his views on the snbject of army reorganisation wonld scarcely meet with general concurrence, becanse of their advanced or radical character. He believed that he went back to the days of the Saxons in this country ; for Blackstone said that King Alfred was the first who established the national militia of this country, and by his prudent discipline made all the citizens of this country soldiers. He would like to see all the citizens of this country what he might call potential soldiers or sailors. He did not mean to say that every man should be a soldier for a large portion of his life: that wonld be a great mistake. His idea was that every man, with the drill he had at school as a yonth, and a short amount of drill afterwards, either in the regular army, militia, or volunteers, might be made a potential soldier capable of taking up arms at a minute's notice. That, he believed, was the only true principle on which to found the army of this country. He would have no substitute, and he might almost say no exemption ; for if the youth of the country were required to undergo a few months' drill between 18 and 20 years of age, no exemption would be necessary. Snch a system would interfere less with indnstry and be less expensive than the present system, and we should not be liable to the panics which from time to time occur in this conntry. He was not one of those who believed that fighting was the be-all and end-all of civilisation ; he believed it was the greatest curse of humanity, but he believed that it was a thing that could better be avoided by our being prepared for it whenever it should threaten us.

Rear-Admiral Inglefield contrasted the condition of the navy, thirty-six years ago with the navy of the present day. Then there was little or no scientific knowledge in the service, and a steam frigate was not dreamt of; now no officer could arrive at the rank of captain withont

having passed an examination and shown that he was not only able to work an engine, but also to explain theoretically all the parts of it. England had now, thanks to the talent, industry, skill, and practical experience which had been brought to bear upon the question, the finest navy in the world, and was equal to the combined fleets of any two European nations. Indeed, he or any admiral in the navy would be glad of the opportunity to command our iron-clad squadron, though he might be sure that he would have to encounter in the Channel the combined fleets of any two European nations.

Mr. Walker, the secretary, then read the following abbreviated report of the society's proceedings during the past year:—"Nine members of the ordinary and seven of the honorary class have been elected. Three gentlemen have ceased to be members, and two—Mr. Keyte and Mr. Seccombe—have been lost to us by death. The total number of members at present on the association's lists are 113 ordinary and 79 honorary members—in all 192. These figures exhibit a steady advancement of the society in numerical strength. Financially, equally wholesome results are apparent. The increase of income over expenditure during the past year is £54 3s. 4d., and the total amount of the general funds of the association at present is £516 3s. 5d. As all excess of money above £500 flows into the superannuation fund of the institution the two financial branches of the association may now be said to be closely connected with each other, although they are actually distinct. The superannuation fund proper has reached £1,072 8s. Id., and it has in no small degree realised the anticipation of its founders. It has strengthened the union between the two sections of the association, and has been a means of which employers and friends have availed themselves freely for the exhibition of good feeling to foremen engineers as a body. The fund, however, effectively to fulfil its objects, should enable the association to increase the superannuation allowed to something greater than the 5s. per week originally designed. To do this a largely increased capital is required, and which the society will spare no pains to accumulate, so as to promote the most philanthropic part of its operations. Our lately established widows' and orphans' fund is advancing towards effective usefulness, and is subscribed to by ninety of our members. Its stipulated allowances are promply paid by the treasurer to the relatives of deceased members, and they provide in some degree against one class of cares when others of the heaviest kind press severely upon the household. Thus, our entire funds amount to a total of £1,600, and we have good reason to believe they will go on increasing. Our library has been augmented by the addition of several standard works, besides current scientific literature. Valuable donations of books have been presented by Sir W. Fairbairn, Bennett Woodcroft, Esq., and Messrs. Atchley and Co. Your committee have been endeavouring to make arrangements to place the library so that it will be at all times accessible, and thus increase the usefulness of those stores of intellectual wealth it contains. Our monthly meetings have been well attended, and continue to be a medium for the exchange of much valuable experience. Papers have been read on 'Deflecting armour-plated Ships,' by Mr. Hyde; on 'The True Means of Estimating the Pressure on the Slide Valve,' by Mr. Briggs; on 'The Engines and Reservoirs of Lambeth and Chelsea Waterworks' by Mr. Irvine; on 'The Water Supply of London,' by Mr. Vincombe; on 'Atmospheric Air combined with Steam as a Motive Power,' by Mr. G. Bell Galloway; on 'The Ventilation of Mines,' by Mr. Cornelius Varley; on 'Boiler Explosions,' by Mr. Galloway, and the annual address by the president, Mr. Newton. A visit of inspection was paid to the works of the Lambeth and Chelsea Water Companies, when upwards of seventy members and friends of the association spent a profitable and pleasant afternoon. This is a portion of the society's proceedings which we trust will not be allowed to fall into disuse, as it is one tending perhaps more than any other to promote friendly acquaintanceship among members, and to increase their professional knowledge. It is hoped the the managers of large works in progress will afford facilities for extending similar favours to the association. The annual address of our president, like many of its predecessors, has at the request of the members of the association been printed, and by the advice of the committee it has appeared with other subjects of importance in the form of a journal, which may appear at regular or irregular intervals, or may cease to appear. It may be, however, that this quiet, unobtrusive journal, heralded by no flourish of trumpets, may make a position in our literature, and find some stratum between the highly scientific and that unrecorded ingrained experience, which we cannot otherwise bequeath to our sons and successors. With good management the journal may be made a great success, nor would that success be at all problematical could we enlist the sympathy and obtain the encouragement and support of the illustrious circle who, by their presence here this evening, thus far signify their approval of the proceedings and the management of the association."

The Chairman next proposed "Prosperity to the Association." He felt, he said, that it was unnecessary to say a single word even in the presence of those employers who for the first time favoured the association with their presence on that occasion in justification of its objects or operations. Having stated what those objects were, he observed that the success of the association had been greater than any one would have dared at the outset to predict, and that not the least gratifying circumstance was the practical manner in which employers showed their sympathy with the association by largely contributing to the superannuation fund. This would have an important and very beneficial influence upon similar institutions already in existence or that might afterwards be established in the country. He now came to the discharge of a very pleasing duty. He was authorised to say that the members of the association had laboured for a long time under a very strong sense of the debt of obligation which they owed to their most respected president, Mr. Newton, for his exertions in the cause of the association for many years past, and the members of the association, not being profound philosophers, and not understanding that deep enjoyment which a man felt from doing good without having it in any way recognised, came to the determination to take some step which would be not at all a satisfaction of the claims of Mr. Newton, but a mark of their esteem and regard for him. He had lying before him a handsome watch and chain, very valuable and very beautiful, which he had been directed to present, along with a purse of sovereigns, to Mr. Newton. On the watch was the following inscription:—"Presented, with a purse of sovereigns, to Joseph Newton, Esq., by the London Association of Foremen Engineers, as a mark of esteem for his valuable services as President during a period of eleven years." The Chairman then presented the watch and purse to Mr. Newton, observing that it would have been impossible for such an association to have attained the position occupied by that of the Foremen Engineers unless the president had been a man of most extraordinary zeal and indefatigable energy. He asked them to drink "Prosperity to the Association," coupling with it the name of Mr. Newton.

Mr. Newton, who was enthusiastically received, responded, and in doing so spoke nearly as follows:—Mr. Chairman, Mr. Deputy-Chairman, Ladies, and Gentlemen,—I find myself face to face with the most difficult task that has ever before fallen to my share. The amount of kindness and generosity which has been lavished upon me to-night has well nigh overwhelmed me, as it certainly most effectually prevents my selection of orthodox and proper words wherewith to express my deep sense of gratitude. The valuable gift which has been conferred upon me to-night in recognition of supposed services rendered to this institution has been increased fifty-fold in value by the manner in which it has been presented and the words with which it has been accompanied. Those words, I have good reason to know, are not the merely complimentary expressions which are expected to be used on such occasions, and which sometimes mean little more than compliment. They are the outpouring of a mind charged with good feeling towards myself, and are made sacred by the seal of friendship with which they are stamped. I am afraid, indeed, that friendship on the part of your chairman has incited him to over-estimate—very much over-estimated—any services which I may have been able to render to this association. At any rate, I feel that I do not deserve so much praise as he has given me, however ready you may all be to endorse his statements. The fact that my fellow members have determined to confer upon me so substantial a mark of their favour has induced me to cast a retrospective glance over my past career in connection with them, and to ask myself the question, Am I entitled to it? The response so warmly made is yours, not mine. I am only conscious of having accepted a post in the first instance which entailed necessarily a considerable amount of labour upon its holder, and of subsequently performing my duty to the best of my humble ability. If this constitutes a valid claim to the rich reward which has been bestowed upon me, I can conscientiously advance thus much in its support. It has been a principle with me throughout life to endeavour to leave things better than I found them. Undoubtedly that has been my desire in reference to this association, and I have worked the more zealously because I knew from the first that it was a good thing to work for, and that many others would reap the fruits of my labour. There are those sitting in the gallery above who could, if they chose, tell you something of the amount of time which I have devoted during the past twelve or fifteen years to effect the advancement of this association, and I know that they have sometimes chided me for preferring its business to the charm of their company. Many friends in time past have questioned me as to why I spent so many of my after hours in working for the society. My answer to mild reproof at home and questions abroad has been "I can't help it, the work must be done." Had I not performed it to the best of my power, I should certainly have dissatisfied myself, and experience has told me that no punishment is more painful than that of self-reproach. Had I done less than I have as president of this association to promote its welfare I should have deemed myself unworthy to hold the office. If you give me more credit than I have

earned that is not my fault, and I would rather submit to be overpraised than sacrifice my self-respect by knowingly doing to little. I am afraid, Mr. Chairman, that I am dwelling over long upon the purely personal part of my present duty, but I feel that it is due to you and to the subscribers to this testimonial to explain, as far as I am able, the sentiments with which your and their excessive kindness has animated me. The sense of that kindness will never leave me so long as consciousness exists, and when that shall have passed away, my gratitude shall be left, with at all events one portion of the testimonial, as a precious legacy to my children. I must say, in addition, upon this portion of my theme, that a knowledge of the fact that employers and foremen alike have contributed to the testimonial is to me a source of the highest gratification. It has been my constant and cherished aim to gain the confidence of both those classes, and the events of this evening convince me that I have succeeded in doing so. I heartily thank you, gentlemen, one and all for this mark of your esteem, this proof of your regard. In proposing the toast of the evening, our excellent friend the chairman spoke of the social and professional value of this institution, and in so doing he has not exaggerated its merits, as he did in my own case. The association is beyond all doubt a most valuable piece of intellectual machinery. Its parts work well together without jarring and without undue friction, and its general result is to turn out foremen who are thoroughly qualified for the duties they have perform, and who are clear-sighted enough to perceive that their masters' interests and their own are one and indivisible. The monthly paper readings and discussions which take place in the handsome apartment of this establishment which to-night is appropriated to the ladies are of great use in developing and utilising the information which each foremen has acquired, and it is impossible for any one to attend them without advantage to himself and, indirectly, to his employers. I say this with all the confidence that arises from practical experience and all the earnestness of honest conviction. I cannot forbear from expressing a hope that honorary members of the association will in the future recognise more fully than they have in the past the usefulness of those monthly meetings, and they will contribute more than they have hitherto done to the enrichment of the proceedings thereat. I can vouch for it that they will always be welcomed most heartily by every member of the ordinary class, all of whom desire closer union with employers. In thanking you Sir, on behalf of the association for your friendly and encouraging expressions allow me also to say that our satisfaction is great in seeing you, in your present important post. We have sympathised with you in the very difficult position in which we know you were placed as a Government officer, and amid the annoyances which we know you have had to bear at the hands of those in authority, some of whom are now, in more respects than one, "all at sea," and without the advantage of your skilful pilotage. In the position of an employer of engineering you are thrice welcome to the presidency over this happy meeting, and in that position we wish you all the success, honour, and prosperity which are its frequent attendants. As the mouthpiece, *pro tem.*, of the association allow me also to say that it greets most heartily those other employers who have honoured it with their presence, and earnestly desires that increasing trade and larger profits may be in store for them all. In conclusion, I beg to submit a toast which only requires mentioning to be appreciated, and which, I am sure, will be received with the utmost favour and evoke all the enthusiasm latent in the breasts of foremen engineers. That toast, Mr. Chairman and gentlemen, is, "Prosperity to engineering employers and success to the engineering trade." It was my intention to have coupled with that toast the names of John Penn, sen., Esq., and John Hick, Esq., M.P. The absence of Mr. Penn, through illness unfortunately, compels a slight deviation from the programme, and I shall associate with the toast the names of John Penn, jun., Esq., and John Hick, Esq., M.P., as representatives of town and country engineering firms.

Mr. Hick, M.P. for Bolton, returned thanks in an eloquent speech, and Mr. John Penn, jun., also responded in modest and very appropriate terms to the toast.

A large number of other toasts were afterwards proposed, prolonging the proceedings till near twelve o'clock.

Various pieces of music were sung between the speeches, under the able direction of Mr. F. A. Bridge.

The evening was evidently satisfactory and agreeable to all present.

The total number of persons recorded at the Board of Trade as having been killed on railways during the year 1870 was 286, and the number of injured was 1,239. In 122 train accidents during 1870, Captain Tyler considers that there was "want of care or mistakes of officers or servants" in eighty-eight instances. In sixty instances "defective signal and point arrangements" were involved; and in forty-three "want of telegraph communication or of system for securing intervals of space between trains."

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

ON THE ALLEGED ACTION OF COLD IN RENDERING IRON AND STEEL BRITTLE.

By J. P. Joule, D.C.L., F.R.S., &c.

As is usual in a severe frost, we have recently heard of many severe accidents consequent upon the fracture of the tires of the wheels of railway carriages. The common-sense explanation of these accidents is, that the ground being harder than usual, the metal with which it is brought into contact is more severely tried than in ordinary circumstances. In order apparently to excuse certain Railway Companies, a pretence has been set up that iron and steel become brittle at a low temperature. This pretence, although put forth in defiance, not only of all we know of the properties of materials, but also of the experience of every-day life, has yet obtained the credence of so many people that I thought it would be useful to make the following simple experiments:—

1st. A freezing mixture of salt and snow was placed on a table. Wires of steel and of iron was stretched so that a part of them was in contact with the freezing mixture, and another part out of it. In every case I tried the wire broke outside of the mixture, showing that it was weaker at 50° F. than at about 12° F.

2nd. I took twelve darning needles of good quality, 3in. long, 1-24th of an inch thick. The ends of these were placed against steel props, $2\frac{1}{2}$in. asunder. In making an experiment, a wire was fastened to the middle of a needle, the other end being attached to a spring weighing machine. This was then pulled until the needle gave way. Six of the needles, taken at random, were tried at a temperature of 55° F., and the remaining six in a freezing mixture, which brought down their temperature to 12° F. The results were as follows:—

Warm Needles.	Cold Needles.
64 oz. broke.	55 oz. broke.
65 „ „	64 „ „
55 „ „	72 „ „
62 „ „	60 „ bent.
44 „ „	68 „ broke.
60 „ bent.	40 „ „
Average $58\frac{1}{3}$	Average $59\frac{5}{6}$

I did not notice any perceptible difference in the perfection of elasticity in the two sets of needles. The result, as far as it goes, is in favour of the cold metal.

3rd. The above are, doubtless, decisive of the question at issue. But as it might be alleged that the violence to which a railway wheel is subjected is more akin to a blow than a steady pull, and as, moreover, the pretended brittleness is attributed more to cast-iron that any other description of the metal, I have made yet another kind of experiment. I got a quantity of cast-iron garden nails, $1\frac{1}{4}$in. long, and $\frac{1}{8}$th of an inch thick in the middle. These I weighed, and selected such as were nearly of the same weight. I then arranged matters so that by removing a prop I could cause the blunt edge of a steel chisel, weighted to 4 lbs. 20 zs., to fall from a given height upon the middle of the nail as it was supported from each end, $\frac{1}{16}$th of an inch asunder. In order to secure the absolute fairness of the trials the nails were taken at random, and an experiment with a cold nail was always alternated with one at the ordinary temperature. The nails to be cooled were placed in a mixture of salt and snow, from which they were removed and struck with the hammer in less than 5″.

Up to Series 10, each set of sixteen nails was made up of those of the previous set which were left unbroken, added to fresh ones to make up the number.

Series 1. Temperature of eight cold nails 10°; of eight warm 36°; height of fall of hammer 2in. Result:—No nails broke.

Series 2. Temperature of eight cold nails 14°; of eight warm ones 36°; fall of hammer $2\frac{1}{2}$in. Result:—No nails broke.

Series 3. Temperature of eight cold nails 2°; of eight others 36°; fall of hammer 3in. Result:—One cold nail broke; No warm one broke.

Series 4. Temperature of eight cold nails 2°; of eight others 36°; fall of hammer $3\frac{1}{2}$in. Result:—Two cold nails broke; one warm one broke.

Series 5. Temperature of eight cold nails 2°; of eight others 36°; fall of hammer 4in. Result:—One broke of each sort.

Series 6. Temperature of eight cold nails 0°; of eight others 38°; fall of hammer $4\frac{1}{2}$in. Result:—One broke of each sort.

Series 7. Temperature of eight cold nails 2°; of eight others 36°; fall of hammer $5\frac{1}{2}$in. Result:—No cold nail broke; one warm nail broke.

Series 8. Temperature of eight cold nails 2°; of eight others 40°; fall of hammer $6\frac{1}{2}$in. Result:—Two cold nails broke; one warm nail broke.

Series 9. Temperature of eight cold nails 2°; of eight others 40°; fall of hammer 7½in. Result:—Three cold nails broke; three warm nails broke.

Series 10. Experiment with the ten left in the last. Temperature of five cold nails 2°; of the five others 40°; fall of hammer 8½in. Resnlt:—Two cold nails broke; one warm nail broke.

Series 11. Experiment with the six left from the last. Temperature of three cold nails 3°; of the other three 40°; fall of hammer 10in. Result:—Two cold nails broke; Three warm nails broke.

Series 12. Experiment with fresh nails. Twelve cooled for four honrs to 3°; Twelve others 41°; fall of hammer 7in. Result:—Seven cold nails broke; eight warm nails broke.

The collective result is that twenty-one cold nails broke and twenty warm ones.

The experiments of Lavoisier and Laplace, of Smeaton, of Dulong and Petit, and of Troughton, conspire in giving a less expansion by heat to steel than iron, especially if the former is in an untempered state. Snch specimens of steel wire and of watch-spring as I possess expand less than iron. But this, as Sir W. Fairbairn observed to me, wonld in certain limits have the effect of strengthening rather than of weakening an iron wheel with a tire of steel.

The general conclusion is this—Frost does *not* make either iron (cast or wronght) or steel brittle, and that accidents arise from the neglect of the companies to submit wheels, axles, and all other parts of their rolling stock to a practical and sufficient test before using them.

EXPERIMENTS ON THE OXIDATION OF IRON.

By Professor F. Crace Calvert, Ph. D., F.R.S., &c.

Some two years since, Sir Charles Fox inqnired of me if I conld give him the exact composition of iron rust, viz., the oxidation found on the surface of metallic iron. I replied that it was admitted by all chemists to be the hydrate of the sesquioxide of iron, containing a trace of ammonia; to this he answered that he had read several books on the subject, in which the statements referring to it differed, and from recent observations he had made he doubted the correctness of the acknowledged composition of iron rust. He further stated that if he took a bar of rusted wronght-iron, and pnt it in violent vibrations, by applying at one end the fall of a hammer, scales wonld be separated which did not appear to him to be the substance I had described.

This conversation induced me to commence a series of experiments which I shall now detail. I first carefnlly analysed some specimens of iron rust, which were procured, as far as possible, from any source of contamination. Thus, one of these samples was supplied to me by Sir Charles Fox, as taken from the outside of Conway Bridge; the other secured by myself at Llangollen, North Wales. These specimens gave the following resnlts when submitted to analysis:—

	Conway Bridge.	Llangollen.
Sesquioxide of iron	93·094	92·900
Protoxide of iron	5·810	6·177
Carbonate of iron	0·900	0·617
Silica	0·196	0·121
Ammonia	trace	trace
Carbonate of lime	—	0·295

These results clearly show the correctness of Sir Charles Fox's foresight, that the composition of the rust of iron is far more complicated than is stated in onr text-books. Therefore the question may be asked. Is the oxidation of iron due to the direct action of the oxygen of the atmosphere, or to the decomposition of its aqueons vapour; or does the very small quantity of carbonic acid which it contains determine or intensify the oxidation of metallic iron? To reply to it I have made a long series of experiments, extending over two years, and which I hope will throw some light on this very important qnestion.

Perfectly cleaned blades of steel and iron having a gutta-percha mass at one end, were introduced in tubes which were placed over a mercury trough, and by a current of pnre oxygen conducted to the top of the experimental tube the atmosphere was displaced, and it was then easy to introduce in these tubes traces of moistnre, carbonic acid, and ammonia.

After a period of four months the blades of iron so exposed gave the following results:—

Dry oxygen	No oxidation.
Damp oxygen	In three experiments only one blade slightly oxidised.
Dry carbonic acid	No oxidation.
Damp carbonic acid	Slight appearance of a white precipitate of the iron fonnd to be carbonate of iron. Two only out of six experiments did not give these results.
Dry carbonic acid and oxygen	No oxidation.
Damp oxygen and carbonic acid	Oxidation most rapid, a few hours being snfficient. The blade assumed a dark green colour, which then turned brown-ochre.
Dry oxygen and ammonia	No oxidation.
Damp oxygen and ammonia	No oxidation.

The above results prove that, under the conditions described. pure and dry oxygen does not determine the oxidation of iron, that moist oxygen has only feeble action; dry or moist pure carbonic acid has no action, bnt that moist oxygen containing traces of carbonic acid acts most rapidly on iron, giving rise to protoxide of iron, then to carbonate of the same oxide, and last to a mixture of saline oxide and hydrate of the sesquioxide of iron.

These facts tend to show that carbonic acid is the agent which determines the oxidation of iron, and justifies me in assuming that it is the presence of carbonic acid in the atmosphere, and not its oxygen or its aqueous vapour, which determined the oxidation of iron in common air. Although this statement may be objected to at first sight, on the ground of the small amount of carbonic acid gas existing in the atmosphere, still we must bear in mind that a piece of iron, when exposed to atmospheric influences comes in contact with large qnantities of carbonic acid during twenty-four hours.

These results appeared to me so interesting that I decided to institute several series of experiments.

When perfectly clean blades of the best quality of commercial iron are placed in ordinary Manchester water they rnst with great facility, but if the water is previously well boiled and deprived of oxygen and carbonic acid, they will not rust for several weeks. Again, if a blade of the same metal is half immersed in a bottle containing equal volumes of pure distilled water and oxygen, that portion dipping in the water becomes rapidly covered with the hydrate of the peroxide of iron, whilst the npper part of the blade remains for weeks unoxidised; but if a blade be placed in a mixture of carbonic acid and oxygen, a very different chemical action ensues, as not only that portion of the blade dipping in the water is rapidly attacked, but the upper part of it immediately shows the result of chemical action, and also the snbsequent chemical reactions are greatly modified by the presence of the carbonic acid. For in this case that portion of the blade is only covered with a film of carbon, together with a dark deposit, composed of carbonate of the protoxide and hydrate of the sesquioxide. The fluid, instead of remaining clear, becomes turbid.

These series of experiments snbstantiate the interesting fact observed —that carbonic acid promotes oxidation.

A long series of experiments were also made to try and throw some light on the curious fact first published by Berzelius, snbseqnently studied by other chemists, and well known to soap and alkali mannfacturers, namely, that caustic alkalies prevent the oxidation of iron; my researches can be resumed as follows:—

(1st) That the carbonates and bicarbonates of the alkalies possess the same property as their hydrates; and (2nd). That if an iron blade is half immersed in a solution of the above-mentioned carbonates, they exert snch a preservative influence on that portion of the bar which is exposed to an atmosphere of common air (oxygen and carbonic acid), that it does not oxidiso even after a period of two years.

Similar results were obtained with sea water to which had been added carbonatcs of potash and soda.

THE MANCHESTER STEAM USERS' ASSOCIATION.

ANNUAL REPORT OF THE COMMITTEE OF MANAGEMENT.

The following is a statement of the nnmber of members of the association on the 31st December, 1870, the number of boilers under inspection, and the revenne of the association for the year:—

Year.	No. of Members.	No. of Works.	No. of Boilers.	Subscriptions, Special Service Fecs, &c.
1870.	642	834	2,116	£4,092 11s. 6d.

The committee have again the pleasure of presenting to the subscribers a satisfactory financial statement. The past year has been one of steady progress; the number of boilers under the inspection of the association on the 31st December, 1870, exceeds that of the corresponding period of 1869, by 81; while the amount of subscriptions is the highest yet realised, and shows an increaso over the previous year of £93 11s. 4d. The revenue of the year exceeds the expenditure by the sum of £287 10s. 2d., and this, after writing off the amount of £67 1s. 7d., composed of varions items reckoned as assets in previous years, but which cannot be realised. Tho credit balance has been carriod to the reserve fund, and the value

of this fund is now £3,504 12s. 7d., which, added to the guarantee of £13,000, makes the total amount of the guarantee fund, on the 31st December, 1870, £16,504 12s. 7d.

During the year the sum of £1,000 has been invested with the Ashton-under-Lyne Corporation as a loan, to bear interest at the rate of 4 per cent. per annum, an increase of 2 per cent. as compared with the bank rate.

No explosion has occurred to any boiler under the inspection of the association during the year, and, consequently, no item for compensation appears in the accounts.

The number of examinations of boilers made during the year exceeds that for the year 1869, by 899. The number of "Entire" examinations made in 1870 is 1,988, which, added to the "Internal" and the "Flue" examinations, gives a total of 2,159. This result the committee note with much pleasure. The executive of the association have always held that if steam boilers recived a periodical, careful "entire" examination, by competent inspectors, boiler explosions would seldom be heard of. It was the object of this association at its formation to secure this examination for the boilers of its members, and year after year this object has been constantly kept in view and every effort put forth to realise it. No guarantee is given of a boiler without such an examination having first been made, while the continuance of the guarantee depends upon the repetition of the examination every twelve months. The guarantee of the association is thus in reality a pledge of safety, and not at all a simple insurance as in the case of a Fire Insurance, &c. At all public holidays the inspectors, as well as the chief engineer's assistants in the offices, are placed at the service of the members for making these "entire" examinations, and it is by the members availing themselves of the public and local holidays, as well as of the inspectors' ordinary periodical visits, that the high number of examinations recorded has been attained. This part of the service absorbs a large portion of the association's revenue. Did the association exist for the purpose of money making, it would pay far better to average the risk incurred in giving a pecuniary guarantee of all the boilers of its members, and pay compensation when explosion took place, rather than to follow the course adopted of examining every boiler in order to discover the weak points of the few. Such a course would, however, be entirely opposed to the fundamental principle of the association.

Although, as previously stated, no explosion has taken place during the past year of any boiler under the association's inspection, yet the number of explosions of boilers not under its inspection has realised the annual average of these sad catastrophes, there having been during the year 1870, 51 explosions, by which 78 persons lost their lives, and 106 others sustained bodily injury. To one of these explosions the committee may make brief reference. It occurred at Liverpool, in October, killing 4 persons and injuring 4 others. Full details are given in the printed monthly report of the association's chief engineer for October, 1870. The committee single it out for notice on account of its attendant circumstances. The boiler was at work in a crowded locality, and the devastation caused by the explosion was widely spread. Many houses in the streets adjoining the works where the boiler was employed were shattered, and several passengers on the public thoroughfares were struck by the *débris*, while parts of the boiler entered two dwelling-houses, killing one of the inmates and injuring others. This explosion illustrates how much the interests of the general public, unconnected with the use of steam, are concerned in the prevention of boiler explosions.

The committee record with satisfaction that the subject of boiler explosions has received a good deal of public attention during the past year. It was stated in the last annual report that Mr. Sheridan, M.P., had introduced into Parliament a bill providing for the compulsory examination of steam boilers by the Board of Trade, and in one of the resolutions of the last annual meeting the committee were requested to watch the Parliamentary proceedings, and to take such steps as might be calculated to diminish the loss of life from boiler explosions, and at the same time protect steam users from harassing Governmental interference. Early in the year the committee took into consideration the subject of Governmental legislation, and at a special meeting, at which Mr. John Hick, M.P. for Bolton, was present by request, the following resolution was passed: "That this meeting is unanimously of opinion that the Government should enforce the periodical inspection of steam boilers, but that the Government should not itself carry out such inspections." A further resolution was also passed urging on Mr. Hick, M.P., the importance of opposing Mr. Sheridan's bill, and suggesting the desirability, if possible, of securing the appointment of a select committee of the House of Commons to consider the whole question of boiler inspection. A printed letter, signed by the president, embodying the resolutions arrived at by the committee at the meeting just referred to, was addressed to Mr. Hick, M.P., and a copy of the letter forwarded to each member of the House of Commons.

Mr. Hick succeeded without difficulty in obtaining the appointment of a select committee, which consisted of nineteen members, and of which committee Mr. Hick was appointed chairman.

This committee took a large amount of evidence, and amongst other gentlemen summoned before it were the president and the chief engineer of this association; the chairman and the chief engineer of the National Boiler Insurance Company; the chairman and the chief engineer of the Boiler Insurance and Steam Power Company; and the chairman and the chief engineer of the Midland Steam Boiler Inspection and Insurance Company. The select committee were unable to complete their inquiry, and they agreed to report the evidence they had taken to the House, and to recommend the re-appointment of the committee to the next session to complete the inquiry and report thereon. The report of the evidence taken before the committee may be obtained from Messrs. Eyre and Spottiswoode, Sale Office, House of Lords, for the sum of 1s. 8d., including postage.

At the meeting of the British Association for the Advancement of Science, held at Liverpool in the autumn, an interesting report* on the subject of Steam Boiler Legislation was presented in the mechanical section. The committee who drew up the report urged that the Government should enforce the periodical inspection of all steam boilers, but that it should not itself turn boiler inspector, while they strongly objected to the principle of insurance as at present applied to steam boilers by joint stock companies, as inadequate to the prevention of explosions.

The committee purpose transmitting a copy of the resolutions passed† to the select committee of the House of Commons when re-appointed, and also to forward any resolutions bearing upon the same subject that may be passed at the approaching annual meeting of this association.

The subject of steam boiler legislation will doubtless make progress during the session of Parliament, 1871, and the committee confidently hope that the ultimate result will be the establishment of such a system of boiler inspection as shall be adequate to the prevention of steam boiler explosions, and at the same time not unduly interfere with the liberty of the steam user. To the attainment of this end the earnest efforts of the committee will continue to be directed.

The committee close this report by asking for the personal interest of each of the present members of the association in extending its influence and area.

On behalf of the committee,

William Fairbairn, Chairman.
Robert Tonge, Secretary.

41, Corporation-street, Manchester, Feb. 14, 1871.

SOCIETY OF ARTS.

THE PATENT LAWS AND THEIR ADMINISTRATION: WITH SUGGESTIONS FOR THEIR AMENDMENT.

By Mr. A. V. Newton.

In bringing the subject of the patent laws and their administration under discussion at the Society of Arts, I am but renewing an attempt made in the year 1851, at the Institution of Civil Engineers, viz., to fix public attention on the points to be considered and disposed of, preparatory to the enactment by the Legislature of substantial changes, calculated to meet the reasonable demands of the manufacturing community.

The subject, thus limited, being more than sufficient for one paper, I would gladly have avoided touching upon the policy of creating a legal property in inventions, but the practice that obtains, in discussing the patent laws, seems not merely to warrant, but to demand, a prefatory analysis of the objections which have been urged against remunerating inventors by conferring on them a legal property in their mental labours.

Section I.

As it is profitless to deal with generalities, the leading objections raised by gentlemen of eminence opposed to the policy of a patent law will be referred to and examined, recourse being had for my examples to that very useful volume compiled by Mr. Macfie, the member for Leith, into which all the evils, real or imaginary, that have been placed to the account of the patent law, are collected. All students of Mr. Macfie's volume will allow that what the opponents of patent law realise to themselves as the chief difficulty to the wide acceptance of their deductions, is the close connection between copyright and patent-right, which privileges, according to general belief, must stand or fall together. It has therefore been their first object to distinguish between these two

* See The Artizan page 278, vol. 28. for Dec., 1870.
† See The Artizan, page 42, vol. 29, for February 1871.

kinds of property, and to show that whilo the action of one is necessarily to limit the field of mental labour, the other has no such tendency. Whether copyright is or is not akin to patent-right, is, in my jndgment, a matter of little moment, for I thiuk that if patent-right cannot stand on its own merits, its analogy to copyright would fail in supporting it. Perhaps the most formidable assailant of the patent laws is Sir Roundell Palmer, who from his high legal attainments, and from the fact of his having bcen (as chief law offioer of the crown) engaged in administering the laws, necessarily carries great weight with the public. In seconding a motion of Mr. Macfie, in the House of Commons, iu the session of 1869, directed to the abolition of patents for inventions, he is reported to have said that "some persons imagined that there was a sort of natural or moral right in inventors to some sueh proteotion as was given by patents, and tho principle was sometimes expressed in this way,—that a man had a right to the fruit of his brain. Now, he held that invention and discovery wcre essentially unlike copyright; copyright applied to a creation." But does not patent-right equally apply to a creation? and, if so, why should one be granted and the other withheld? An extract from a specch of M. Michel Chevalier, in Mr. Maefie's book, will serve to illustrate the similarity of the work undertaken by an inventor and a literateur. He says:—"In the detail treatises on meohanics, physics, and chemistry, iu books of technology, with their accompanying illustrations, snch as are now pnblished, we find an indefinite quantity of combinations of elementary apparatus, especially of mechauioal arrangements, and very often the work of professional patentees consists in searching throngh these so numerous collections for uses and arrangements which they combine and group." Now, is not this precisely the same kind of work as that performed by the author of "The Book of Praise," and for whioh Sir Roundell Palmer holds, I presume, a copyright? Sir Roundell Palmer further says:—"He could not allow that the man who was first in the race of discovery could claim for fourteen years or any other term, an exclusive property in a portion of the common stock of knowledge which was accessible to all who used the proper means of discovering it." Now, withont questioning the phraseology of this sentence, which implies that knowledge may bc hidden or unknown; bnt taking the expression as explained by the context, it may suffice to reply that the patent law does not confer on the first discovercr of a law of nature an exclnsive right to the use or application of that law. This, in the abstract, Sir R. Palmer, as a lawyer, will admit, but possibly with the reservation that the first practical application of a newly discovered law, brought out concurrently with the announcement of the law itself, under the proteotion of a patent, substantiates the truth of the statemeut. Experience, however, shows that it requires the labour of many minds to reach such an end as this. Thus, in general, we have first, the experimental philosopher who infers the existence of the law; then, the demonstrator of the laws's existeuce; then, perhaps, the definer of the law's limits; then comes the sniggester of the uses which the law may subserve; and lastly, the practical exponent of its uses. The patent law does not touch the disoovery nntil it arrives at the last stage, as witness the course of discovery extending over a century, to which the electric telegraph of Cook and Wheatstone was due; and then, so far from "the facts which lay in Nature itself" being monopolised, the contrivances put forth under the stimulns of the patent law to utilise them are legion. This objection, therefore, of Sir R. Palmer falls to the ground. Equally untenablo is that which his experience as an advoeate in the courts of law suggested. In speaking of patent trials, he said:—"Everybody was aware that snch litigation had acquired a reputation infamons beyond every other." Bnt it may be asked is this a reason why patents should not be granted? If such litigatiou be "infamous," and I shonld be the last person to deny it, should not tho character of the litigation be changed rather than the ground for the litigatiou destroyed? But more of this anon.

Without going the length of denouuoing patents, Lord Stanley (now the Earl of Derby) when addressiug himself to Mr. Macfie's motion, said that the objections which he felt to the prineiple of patents were threefold:

First, "You conld hardly ever secure the reward going to the right man." Second, "Yon conld not establish any proportion between tho public service rendered, and the valne of the reward received nominally for that service." But if we admit for the sake of argument, the truth of these objections, may they not be answered by the question, "Is there any need to ensure those results?" The motive for the grant of patents is not the apportionment of rowards but it is thus expressed in the patent itself:—"We being willing to give encouragement to all arts and inventions which may be for the public good." The question therefore is, "Do patents afford the necessary encouragemont?" and if they do, that is all the nation is conoerned with. It is for the individnal to secure, by his prudence, the reward which he has earned by his ingenuity; and it is no matter how great the reward may be which the patent affords, seeing that its extended use, while enlarging the inventor's profits, must, to a corresponding extent, bencfit the public, however little comparative merit the invention may exhibit.

The third objection is, "You could not prevent very great inconvenience and injury being inflicted upon third parties." Here his lordship had in mind a race between some half-dozen meu, who independently had hit npon the same invention, and who all equally deserved, while but one could secure the patent for that invention. This is but a snpposititious case with which the public has no concern; which represents a risk that may or may not be possible, and that is as likely to be met with in any other field of speculative industry.

I do not care to traverse all the ground gone over by Mr. Macfie in his pnblished "notes" of a speech delivered in the House of Commons, on the motion above referred to; but as he cites the action of the Dutch Legislature with respect to patents, as a strong reason why the British Legislature should declare that, in the words of his motion, "the time has arrived when the interests of trade and commerce, and the progress of the arts and sciences in this country would be promoted by the abolition of patents for inventions," I will attempt to show, from his own book, that the cited case does not apply. In a speech delivered by M. van Zinnicq Bergmann, in the second chamber of the Netherlands Legislature, on the discussion of the projected law for abolishing patent-right, he is repnted to have said:—"We are continnally referred to England and the United States; bnt what is England? England is a country at the same time emancipated and in course of emancipation. Duly considered, England will be found to be internally in about the same state in which the Netherlands were before 1795, or before the end of the sixteenth century." Thus, according to this enlightened legislator, we have still nearly two centuries of lee-way to fetch up before we attain the position reached by the Netherlands, and are in the blissful condition, withont disadvantage to the State, to abolish patents.

With respect to Mr. Macfie's main objection to patents, viz., that throngh their operation "British and Irish manufacturing pre-eminence is passing away," I do not care to meet it here, as an opportunity was afforded me at the Social Science Congress at Bristol, and again iu the preparation of a petition, which was presented to the House of Commons at the end of last session, to show, by reference to the Board of Trade returus, that there was no ground for his complaint, but that, on the contrary, there was incontrovertible evidence to show that our export trade had grown enormously of late years, and was still on the increase.

Before leaving this part of the snbject, it may be as well to notioe a remark of Sir William Armstrong, in his address delivered as Presideut of the Economy and Trade Department at the Newcastle Congress of the Social Science Association, in September, 1870. Speaking there in his favourite character of an anti-patent man, he said:—"Copyright involves no monopoly of ideas, but pateut-right does. The field of authorship is not narrowed by copyright, bnt the field of invention is." This pithy statement has doubtless gaiued general acquiescence, but does it really mark a distinction between copyright and patent-right? I thiuk not, and I will attempt to show that, in precisely the same way that patent-right involves a monopoly of the use of an "idea," so does copyright, and that, moreover, for au indefinite period. The "idea" of compiling, for example, such a volume as that well-known book of reference, "Hayden's Dates," is practically held by the publisher of that work under a copyright, the term of which is being constantly extended by the iusertiou of new matter. It is true that others might produce a rival volume, aiming at the same object, but so also may inventors attain, or seek to attaiu, by new and different means, like results to those reached by a successful patentee. The copyright, though it did not extend to a monopoly of the idea, effectnally prevented for a time its being appropriated, by protecting from appropriation tho combination of words embodying the idea, and thus necessitating years of labour iu referring to original sources for the production of a similar work. Thus, indirectly, the copyright in this case played precisely the same part as a patent-right; and, although the idea might be, and was ultimately seized upon, yet the time required to appropriate it cnabled the origiual work so effectually to occupy the ground as to bid defiance to subsequent competition. This example will suffice to show that, although, as Sir W. Armstrong truly says, "the field of authorship is not narrowed by copyright," yet the field of an anthor's remuneratiou is narrowed by the labonrs of another author, aud that iu precisely the same manner as are the labours of one inventor by those of another. And this holds good, more or less, wherever competition is to be found, quite irrespeotive of legal enactments, resort to which is not uufrequent to mitigate competition, a notable instance being the legal apportionment of certain districts to the several metropolitan gas companies.

Section II.

Having answered, as I trust satisfactorily, the objections raised to the principle of a patent-law protection, I come now to consider the requirements of a patent law, and to ascertain how far these requirements are fulfilled by our existing laws. A patent law should assure to inventors

a saleable right to the use of their improvements, and thus enable them to obtain a reasonable remuneration for their labours. This implies not merely the creation of a property recognised by law, bnt the provision of adequate means for protecting the property so created from spoliation. That property is created by the action of the present laws, notwithstanding their defects, no one will deny, but who will dare to say that it is adequately protected? The wealthy owner, it is trne, may maintain the rights, but how is it if a poor patentee is matched against a rich infringer? Moreover, as Mr. Macfie tells us, patentees are "trusted with letters of marque to prey, not on foreign commerce, but on British," and there is some ground for this assertion. Indeed, experience shows that it is absolutely necessary to provide against a great good being converted to evil uses. The cause of these acknowledged defects is now beginning to be admitted by our judges, but we are apparently as far as ever from securing a remedy. Yet the remedy for that state of things, which Sir R. Palmer denounces as "infamous," is of the simplest kind. It is not to be found in the erection of a special tribunal for the trial of patent causes, so often advocated, nor in the reconstrnction of existing courts, though these may have their use, but in an official preliminary examination of every complaint of infringement, and likewise of every answer to such complaints, with a view of weeding out groundless actions and keeping asunder the parties to the dispute, or allowing them to go into court only to settle differences on ascertained and definite points. The policy of exercising a controlling power over intending litigants is not such an entire novelty as may, perhaps, be supposed, for under the Scotch Judicature Act, 13, 14, Vic. cap. 36, sec. 38, a somewhat similar process has long been pursued, as will be seen from the following extract, taken from a work by Messrs. Macfarlane and Cleghorn, entitled "Practical Notes on the Structure of Issues in Jury Cases in the Court of Session;"*—"It becomes necessary, therefore, preliminary to going before a jury, to analyse the record, and to review and collate it; to throw aside admitted points, and thus by laying out of view all unnecessary matter, the real question or questions to be tried stand out separately and disencumbered. It may, and does freqnently happen, when a case is so analysed, that, contrary to the anticipations and views of both parties, there is truly no relevant matter for trial at all. When this occurs, no issue can of course be granted, the parties being either at once sent out of court, or obliged to amend their pleadings; or it may happen that, the parties being agreed on all the material facts, the hinging point is one purely and entirely of law. Neither in such case is any issue framed for trial by a jury, the discussion being left to be raised by the parties and disposed of by the court on the record as it stands.

Here then, we have a means of controlling the right of action, which lawyers are too apt to consider as the birthright of every British subject; and if this controlling power obtains in Scotland, why should it not be extended to England, more especially if it be limited, as is now suggested, to patent suits, the right to pursne which is at present granted without reserve, and has undoubtedly, in some few instances, been "used as letters of marque to prey on British commerce."

In a paper read before the Social Science Congress at Birmingham, I sketched out a plan, firstly, for subjecting the complaints, of intending suitors, and the answers to their complaints to a searohing investigatiou, with the view of arrestiug *in limine* factious disputes; and, secondly, for shaping for trial cases possessing matter worthy of the attention of the courts. By reference to a variety of cases, I illustrated the working of the proposed amendments, and showed what an amouut of litigation would be avoid, ruinous alike to plaintiff and defendant, both in temper and purse, by empowering an examining officer to bring the parties to a suit to a proper understanding of their respective legal positions, before allowing the suit to be commenced.

This course of proceeding has, from its reasonableness, been approved, in principle, by chambers of commerce, and also by the Patent Laws Committee appointed by the Social Science Association in the year 1866, whose report (drawn up by Mr. Webster, Q.C.) contains the following resolution:—"That no proceedings for the infringement of pateuts should be commenced, except upon the certificate of a competent examining officer. That the application for such certificate shonld be founded on a written statement, specifying the part of the invention alleged to have been infringed, and the manner of such infringement, by which statement the plaintiff should be bound in any subsequent proceedings upon the patent." A similar suggestion is made by Dr. Pankhurst, in a very clever and instructive paper which he read before the British Association at their last meeting at Liverpool, for he recommends "that, prior to the institution of proceedings for infringement, the report of an examining officer should be obtained, based upon the statement of the applicant as to the precise nature and extent of the infringement." In the same spirit, the *Times* of April 3rd, 1868, said:—

* T. and T. Clarke, Edinburgh; and Benning and Co., London

"Perhap it might be possible to provide some mode whereby causes o action might be brought under jndical cognizance, so to speak, *in ovo*, with a view to procuring an impartial opinion on their *primâ-facie* validity."

It would tedious to quote the many expressions of opinion which our judges have, of late years, delivered, tending to show the necessity for the adoption of some system of weeding out from the cause list cases that, either from the character of the complaint, or the defence, or from their unprepared state, ought not to be brought into conrt; but I cannot refrain from giving the following examples:—

Lord Chancellor Westbury, in the course of the famous sewing machine case, "Foxwell *v.* Bostock," said:—"You see how much evidence is thrown away, and how much effort of the counsel becomes useless, unless you first of all determine what is the meaning of the specification." Again, in the case of "Fells *v.* Barnet," Mr. Justice Bramwell observed, that "he wished he had, by law, the power of certifying, in certain cases, that the plaintiff's attorney should pay the costs of the action when wholly unfounded." This may be considered a harsh measure, but it is the learned judge's way of meeting some of the difficulties which a preliminary official examination is intended to remove.

Mr. W. T. S. Danniel gives us the following as the result of his experience as a County Court Judge. He says, "I think it is a very great advantage, in many cases, to the rightful suitor, that the power and influence of the judge should be brought to bear, at the earliest possible stage, upon the subject of litigation and the conscience of the litigants." If "examiner" be substituted for "judge," we shall find here not merely the principle but the system for which I contend; and its adoption would not only allay much of the enmity existing against patent-rights, by removing the cause therefor, but would be the means of increasing the saleable value of patents, by providing an inexpensive test of their validity.

Section III.

Passing on to that part of the question which relates to the mode of granting patents, I must say that, whatever may be my convictions as to the necessity of the case, I cannot overlook the fact that there is a strong bias of opiuion as to the advantages of a preliminary examination before a patent is granted.

On referring to the resolutions of the Patent-laws Committee of the British Association, agreed upon in London in the year 1861 (of which Committee Mr. Macrory, the patent counsel, acted as secretary), I find the following:—"That all applications for grants of letters-patent should be subjected to a preliminary investigation before a special tribunal, and that such tribunal shall have power to decide on the granting of patents, but it shall be open to inventors to renew their application, notwithstanding previous refusal."

In the report already referred to as emanating from a Committee of the Social Science Association, one of the resolutions therein contained is:—"That patents should be granted ouly after examination and report of competent examining officers as to the novelty of the invention, as to its being the subject-matter for letters-patent, and as to the sufficiency of the provisional specification." Again, Mr. Aston, barrister-at-law, in a paper on the patent-laws, read before an influential meeting at the Manchester Institution of Engineers, in January, 1870, recommends "the exercise of discrimination in granting patents, so as to prevent them from being repeatedly granted for the same invention, and granted for alleged inventions that clearly have no claims to be so considered." So, also, Dr. Pankhurst, in his paper already referred to, suggests that "the grant of a patent should be preceded by an examiuation by competent examining officers.

I might multiply examples of this kind, but those cited will suffice to show how general is the conviction of the advantage and even necessity for a preliminary investigation. But do they who advise it know how mnch it involves? Mr. Aston seems prepared to accept the consequences, for he distinctly advocates the adoption of the system now in force in the United States.

It is well that we should understand what machinery is required for securing a preliminary examination before we decide on recommendiug its adoption, We gather from a speech of the late American Commissioner of Patents* that although he is provided with sixty-two examiners, they are overcrowded with work, and that a force of over three hundred *employés* is maintained in the Washington Patent Office. It is also clear that this staff has gradually reached its present proportions, for it is stated that "in the Patent-office, under the Act of 1836, the commissioner and one examining clerk were thought to be sufficient to do the work of examining into the patentability of the two or three hundred applications that were offered." In his last annual report, the commissioner says, "Few persons realise the rapid growth of the office

* Speech delivered before the American Institution, by the Hon. S. S. Fisher, late Commissioner of Patents.

and the annual accretion of material. The models increase at the rate of one hundred square feet per week, or five thousand square feet per annum. The drawings increase at the rate of twenty cubic feet per annum; the files at the rate of four hundred cubic feet; the printed specifications at the rate of four hundred and twenty-five cubic feet; the printed drawings at the rate of four hundred cubic feet;" and it is the duty of examiners constantly to probe to the bottom this ever-increasing mass, in order to test the novelty of every application for a patent. Of course, if the English government is willing to accept this duty, neither patentees nor their professional advisers can object; but there is a great, and as I think, an insuperable difficulty in carrying out such an investigation. The means for effecting it do not exist, and they cannot be created by a word. The American Commissioner says that "an examiner should be a man of great patience, industry, and honesty, of varied and yet thorough mechanical and scientific attainments, with a good knowledge of patent law, and a mind capable of the nicest discrimination. Though many men offer themselves for the position, but few are fit to fill it." And again, "An examiner must familiarise himself with all the inventions that have been made in his class, not only in this country but in Europe. Their great number and complexity have rendered the study of them a profession to be acquired by years of labour." This is not an encouraging picture of the requirements for an office to be created, and which, judging from the experience of the Patent-office at Washington, will require the labour of many years to bring to efficiency. If, therefore, an examination is to be adopted, it must be introduced gradually, and at the discretion of a responsible commissioner. This is the only practicable plan: for it is evident that the examiners would have to be educated to their work. Had our Patent-office been conducted under the new law as it should have been, we might, by this time, have possessed some few men qualified for this new duty; but every obstacle that could be created has been employed, as if to frustrate this object. When Mr. Woodcroft was appointed to the office of superintendent of the specifications, he obtained the sanction of the commissioners to publish abridgements of the specifications, and no one connected with the office being found capable of compiling these abridgements, external assistance was sought. At the instance of a friend, professionally qualified for this work, I preferred his request for a subject to abridge for publication, but was met with the reply that the commissioners had ruled that no patent agent should be entrusted with that duty. Some years after, I discovered the key to the seeming mystery, why those who had prepared the original documents were deemed incompetent to abridge them. On examining a publication entitled "The Edmunds Scandal," compiled by Mr. Leonard Edmunds, of Patent-office notoriety, I found (at page 81) the following statement:—"The business of 'abridgements' was a job from the first conception; totally unqualified persons (patent agents, people of no calling or profession whatever) were, in the onset, employed on the work. I very soon made that discovery, and accordingly I insisted that none other than properly-qualified practising barristers, having a knowledge of the patent-laws, should be employed. I believed I had taken effective measures to that end."

It will be readily understood what the best intentions could effect when they were carried out under the advice of a man of Mr. Edmund's calibre. That these abridgements are, from their faulty conception and execution, of little use, is a small matter compared to the loss of the opportunity which their preparation afforded of educating men of suitable qualifications for the duties of examiners.

The American commissioner, in speaking of the task of examination, says:—"It would be impossible to make it (the examination) without a careful classification of the subjects of invention." Now this is precisely the thing which inventors have in vain sought for. A complaint of this want in the Patent-office was brought under the notice of the commissioners some four years ago, and it resulted in an order of a somewhat extraordinary character. It had been the practice in the Patent-office to remunerate the gentlemen engaged in making the abridgements at a liberal rate per specification, but the result not having proved entirely satisfactory to the public, the commissioners made an order that, after the 31st December, 1866, every applicant for letters patent should deliver with his provisional specification an abridgement of the same in duplicate. Thus, at last, the duty of preparing abridgements was thrown upon the patent agents, "people of no calling or profession whatever," as Mr. Edmunds called them; but a little fact was forgotten, namely, that the remuneration for this work was not provided for. The consequence has been, as might well be supposed, that the abridgements are worthless; and yet the commissioners have undertaken to publish them *verbatim*, at the expense of the nation, and to adopt them as a substitute for the paid abridgements heretofore issued by the Patent-office.

Preliminary examinations might, I think, at once be commenced, and that with good effect, but they could not be of that thorough character which all, or nearly all, the advocates for that course seem to desire. Thus, many applications which contain no proper subject matter for a patent, might, though the fact were ever so skilfully disguised, be rejected, if all applications were submitted to a competent authority. Even now, something of this kind is effected by the law officer. Thus, when spirit-rapping was in vogue, an application was lodged at the Patent-office, on behalf of an American inventor, for a means of testing the presence of spiritual forms, and rendering the same visible to mortal eyes; but protection for the invention was refused, on the ground that it was not a manufacture within the statute. Thus, we do get something for the payment, out of the Patent Fund, of some ten thousand a-year to the law officers of the crown.

Without going the length of condemning as impracticable the adoption of a thorough preliminary examination, the foregoing considerations will, I think, bear me out in these conclusions, namely:—

1. That preparatory to any attempt to work out this idea, complete analytical indexes must be made by persons fully competent to the task.

2. That considerable time must be allowed for the education of examiners, before the system can be applied.

3. That the cost of the work will be very great, and constantly on the increase, and will exceed the advantages that may be expected to accrue therefrom.

It ought also to be remarked, that if the system which I have suggested, of subjecting to an examiner all patents which are intended to be brought under litigation, were adopted, we should arrive virtually at the same result that would be reached by the preliminary examination of applications for patents, for the novelty and utility would be tested in the most effectual way, namely, by the aid of an alleged infringer, whose interest it would be to point out defects in the patent; and beyond this, the examiner would require to be satisfied as to the sufficiency of the specification before permitting an action to be based upon it. Thus, instead of more than three thousand applications per annum being required to be examined, we should have considerably less than thirty, the cost of examining which would fall upon the litigants instead of on the public, while the invalid patents would remain a dead letter, and be perfectly innocuous by reason of the controlling power of the examiner.

With respect to the cost of preliminary examination, I may state that if that course should be adopted, the Patent Fund will, while maintained by the present scale of fees, be ample to meet all requirements. By reference to a return, ordered by the House of Commons, on the motion of Mr. James Howard, it appears that, up to the end of 1867, there was a surplus of receipts over expenditure, since the commencement of the Act of 1852, amounting to £660,247 15s. 3d., notwithstanding the payment to the law officers and their clerks of £155,175 8s. for their perfunctory duties, and of the payment, in the shape of pension, to the law officers of Ireland and Scotland and their clerks, of £54,189, and this surplus is estimated to increase at the rate of £70,000 per annum.

Section IV.

Although a strong feeling exists in favour of a preliminary examination, there is a diversity of opinion respecting the nature and extent of such examination. Some would limit it to an inquiry into the sufficiency of the provisional specification, and to the invention therein described being a proper subject for a patent. Others would, in addition, extend it to novelty and utility; and others, again, would bring the complete specification under examination, with the view of giving definiteness and precision to the appended claims, thus incidentally withdrawing the privilege peculiar to English patentees, of embodying in the complete specifications the practical experiences of several months of public working.

As an advocate of the last course, we find Mr. Aston, in his paper already referred to, suggesting "the deposit, before the patent is granted, of a precise description of the invention and claims given, in a complete specification, which should be submitted to a proper official examination before it is passed as sufficient." This is, in fact, a recurrence to the American practice, with which Mr. Aston says he is practically acquainted.

In proposing this change, I would ask, is Mr. Aston prepared to advise the adoption of the American equivalent for our six months' protection, or does he ignore altogether the claim of an inventor to the consideration shown by our existing law, in allowing practical experiments to precede the deposit of the complete specifications? For my own part, I think that the advantage of delaying the filing of the complete specification is so great and so obvious, that very strong reasons must be advanced, before inventors will consent to forego this privilege.

The substitute provided by the American law may be thus summarised. In the first place, the law recognises a property in an invention so soon as it is embodied in a practical shape, in the same way that our copyright law recognises a property in an unpublished work. In the second place, "caveats," embracing descriptions of unpublished inventions, may be filed in the secret archives of the Patent-office; and all applications for patents made subsequently to the filing of such caveats will be

liable to be rejected, if they are found to interfere with these private memoranda. And, in the third place, patents, when granted, may be withdrawn, and re-issued with an amended specification, and claims appended thereto.

These are important privileges, and it is essential that we should understand their action. For this purpose I must again refer to the last annual report of the American Commissioner of Patents. He says:—"It has been held in one case that, upon an application for a re-issue of a patent, new matter might be introduced into the specifications and drawings. In another case, that upon the decision of an application for a new issue, the patent must be dated back to the date of filing (in one case four years), thus making infringers of manufacturers who were using the invention ignorantly during all the time it was locked up in the secret archives of the office, and while it was impossible for them to know of the existence or character of the claims. In another, that an applicant who had filed an application and withdrawn it eight years before, might re-file it, and obtain a patent for seventeen years from the present date, although the same thing had long since gone into public use, and was incorporated in the mechanism of many subsequent inventions."

Are these new elements of doubt and uncertainty desirable adjuncts to our patent system? Yet it is these elements, as I understand from his paper, that Mr. Aston is willing to accept as a lesser evil than that of allowing patentees to define, on their own responsibility, the limits of their inventions. He complains, and not without reason, that most confused and elastic claims can be made by a patentee, so as to prevent the public from ascertaining what is intended to be claimed. But will an examination like that adopted in the United States afford a better result? I think not. To test this, I open, at hazard, a volume of the American Patent-office reports, containing the claims of all the patents granted for the year 1859, and the first claim I see is the following:—"The arrangement of the frame A, hopper B, partition N, adjustable slide M, valve L, cylinder H, concave I, adjustable slide J, and flexible clasps K; the whole being constructed and operated as and for the purpose set forth." Now, here is a reference to every essential part of the patented machine; and the claim is evidently what we should, in England, call a combination claim. Does it clear the matter at all to name the several parts to be found in the combination; or would not the claim be as intelligible if put into the English form, as, for example;—The arrangement of parts, as above set forth, as constituting my improved machine?" The latter specimen is, in my judgment, the clearer of the two. Although grave exception may be taken to some of our specifications, on the score of vagueness, yet, upon the whole, they are far more definite than those of any other country; and yet it appears to me most unjust that a patentee, in making his claims, should have to use some arbitrary formula, as is the case when registering under the Non-ornamental Designs Act, which formula cannot be made to fit all cases. It would seem reasonable that, when the public finds a difficulty in ascertaining the meaning of any public document, resort should be had to those whose business it is to understand and interpret it. If it should be determined to adopt a real preliminary examination of any kind, the executive duties of the attorney and solicitor-general, so far as concerns the granting of patents, must necessarily cease. This is a result which all the advocates for a reform of the patent laws appear to desire. The only disadvantage which I think can arise from this change is, that our future judges will be less able to deal with cases of infringement than those who, as law officers, passed a kind of an apprenticeship to patent-law duties. I might speak of many changes in the law which require to be made in the event of any new legislation, with a view of cancelling certain injurious provisions unknown to the old law, and of removing some disabilities which have arisen in the working of the new system. But I pass on to matters of more importance.

Section V.

Under the old system of granting patents, oppositions to applications formed an important feature of the business, and it was considered by advocates for a reform that oppositions should be rather facilitated than discouraged, as the public would thereby be able to check the grant of patents which might otherwise injuriously interfere with established manufactures. The duty of hearing and deciding upon oppositions is still retained by the law officers, but their reading of their duties is, under the new law, essentially different from that of the old system. The stage of opposition being after the grant of provisional protection, it followed, as a natural consequence, in the mind of a lawyer, that a strong case must be shown to dispossess the proprietor of his protection. Thus, instead of two persons in possession of a knowledge of the same invention, one an applicant for a patent and the other not, being on the same footing before the law officer, as was formerly the case, he was led to consider that, in the absence of fraud, the applicant for the patent must receive the grant. So also if a patentee, speculating on the possibility or probability of a new application interfering with his rights opposes that application, and fails to show a similarity of invention, he runs the risk of being mulcted in costs, the act of opposition being considered an unwarrantable interference with a private interest, instead of the vigilant exercise of a public duty. The effect of this practice has been to deter the public from opposing applications for patents, and thus applicants have only to fear the inquisitorial power of the law officers; in other words, the check which formerly existed to the indiscriminate grant of patents has been removed.* If preliminary examination, even in its most limited sense, should be adopted, the necessity in great part for oppositions will be removed; but, in cases where they are resorted to, the proper course will be to have them referred to the examiner-in-chief, or head of the Patent-office.

By the Act of 5, 6 William IV., cap. 83, known as Lord Brougham's Act, patentees were allowed to amend defective specifications on the certificate of one of the law officers, by entering a disclaimer to portions of the same, and introducing such amendments as did not extend the scope of the specification. By the same Act, the Judicial Committee of the Privy Council was empowered to examine into the merits of applications for the extension of expiring patents, and recommend to the Crown to extend the same for a term not exceeding seven years. Unfortunately, however, the merits of this law have been greatly circumscribed by the machinery devised for working it, for the administrative power was placed in the hands of men who seem unable, from their education and pursuits, to appreciate the intention of the legislature in passing the Act. Sympathy in the administrators of a new law with the interests of those for whom that law was enacted, is essential to the proper working out of the intentions of the legislature, and that is precisely what has been wanting in this case. The granting of disclaimers, moreover, not only needs the exercise of technical knowledge, to say nothing of a careful consideration of every phrase that it is designed to change, and a patient and intelligent attention to the objections which may be urged against the allowance of the disclaimer. Yet this duty is thrown upon the law officers, who rarely possess any technical knowledge of the subject under discussion, and are, perhaps, the most hard-worked men in the kingdom. It is not surprising, therefore, that in the notable case of Medlock's aniline dye patent a disclaimer was refused (or rather granted upon unacceptable conditions), although the amendment proposed was of a nature contemplated by the Act, and even suggested by the Lord Chancellor, whose decision rendered it necessary. Had the law officer who heard this case been aware of the fact that the Disclaimer Act was intended to prevent an infringer availing himself of an oversight of a patentee to rob him of his rights, such a judgment as that referred to could not have been delivered.

Again, with respect to the extension of patents, the patentee desiring an extension is compelled to go before a tribunal utterly ignorant of the exigencies of trade, and having no sympathy with him or his, unless the petitioner happens to be a poor fellow out of luck, or a disconsolate or poverty-stricken widow. In either of these cases, there is a chance of an extension being granted; but let a thriving manufacturer apply to the Privy Council for an extension of a patent from which he has derived, say, some ten thousand or even five thousand pounds during the fourteen years' working, and, though he may be able to show that the public has benefited to the extent of hundreds of thousands of pounds, he will be pretty certain to have his petition refused. If, however, the tribunal to which such matters are referred were practically acquainted with the labours in which inventors are engaged, if it understood the risks to which they are exposed, and the necessity which frequently exists for forcing an invention upon a reluctant public, the refusal of an extension of a patent would be the exception rather than the rule.

In the United States, when the proofs tendered show a patent to have been exceptionally remunerative, that is, in itself, indirect evidence of the invention being of a character to merit extended protection. But, according to our practice, the chief merit of the patentee, in the eyes of the legal branch of the Privy Council, is (and it is not very surprising) that he has been committed to an enormous expenditure in litigation.

As a contrast to this state of things, we have the fact, that when the late Mr. Elias Howe applied for an extension of his American patent for sewing machines, although his accounts showed a profit of £95,000, he obtained an extension for a period of seven years. This favourable decision was secured by the proof that the invention effected "a saving every year of more than one hundred and three times the amount of all the profits which Howe has ever received."

There is no reason why the same principle should not guide the ruling

* The following extract from a decision of a recent law officer will show the spirit in which this important duty is now performed:—"The objection appears to have been taken (there being no evidence before me) entirely upon a supposition that the one (invention) might interfere with the other, and by way of precaution merely. In future, when this in done unsuccessfully, it will be right to give costs against the objector. As this is the first case of the kind before me I do not think it will be right to do so.

of the courts in both countries, for the aim of the laws is identical, viz., amply to reward successful inventors; but the standpoint of the two tribunals is different, and will always remain so until the tribunals themselves are assimilated.

In the United States, the duty of considering applications for extensions is imposed on the Commissioner of Patents, who is the controlling power in all matters relating to the grant of patent privileges, and who, therefore, by reason of his wide experience, is enabled to appreciate all the circumstances which may surround and bear upon the several cases submitted to his consideration. Under these circumstances, it is surprising that some well-defined principles are found to guide the decision of the Commissioner. Thus, for example, in a recent decision (Singer's application for an extension), we find the Commissioner looking carefully to the interests of the public in a direction entirely unknown to our Privy Council, the members of which are ever changing, and are always collected at hap-hazard.

Mr. Commissioner Fisher, deciding against the Singer petition for extension, makes the following important statement in his judgment, wherein it will be seen that, in adjudicating upon extension cases, he, unlike our Privy Council, perceives a "divided duty":—"The public interest requires that when an article has come into general use, all barriers to its free manufacture and sale should be broken down as speedily as possible, consistently with individual right. If an inventor has produced a good thing, but the public are slow to perceive it, if he is obliged to spend the greater part of his original grant in preparing for its manufacture, in slowly bringing it to the public notice, and in demonstrating its utility, and if it appears that, at the expiration of his first term, if the exclusive right is taken away from him, it is probable that all incentive to further invention is likely to be destroyed, and no one else appears ready to step forward and take his place, it is obvious that the public interests might demand an extension of the patent."

(To be Continued.)

INSTITUTION OF CIVIL ENGINEERS.

AN ACCOUNT OF THE BASIN FOR THE BALANCE DOCK, AND OF THE MARINE RAILWAYS IN CONNECTION THEREWITH, AT THE AUSTRIAN NAVAL STATION AT POLA, ON THE ADRIATIC.

By Mr. Hamilton E. Towle, of New York, U.S.A.

The harbour of Pola, naturally favourable for the purposes of a naval station, was selected by a committee of Austrian engineers and officers, as the most suitable that could be chosen for the extensive arsenal and dockyards, which it would be necessary to construct when the port of Venice was abandoned. It was situated directly south of Trieste, on the western coast of the peninsula of Istria, south-west of Fiume, and about 60 miles distant from both those ports. Venice, on the other side of the Adriatic Sea, was 80 miles distant in a north-westerly direction. It was at first intended that excavated docks should be formed, but, in consequence of the volcanic and treacherous nature of the ground, this idea was found to be impossible of execution. A Floating Dock, Basin and Railway system were therefore decided upon, the dock adopted being that known as Gilbert's Balance Floating Dock. The basin and railways were in general principles the same as those constructed at the United States' Navy Yards at Portsmouth, New Hampshire, and at Pensacola, Florida. These were the first dock basins with railways that had been constructed, and were commenced in the year 1849. The function of a basin for a floating dock was to supply a place in which the dock itself might be grounded, either with a vessel upon it to undergo extensive and prolonged repairs, or to enable the vessel to be hauled out of the floating dock upon the railways, which latter operation was only required in cases where vessels were moved from the dock to land above the sea level, or the reverse. A basin to fulfil these requirements must be so constructed as to permit the dock to be floated into it, and the entrance closed by means of gates or caissons. The general dimensions of the basin at Pola, determined by the magnitude of the floating dock, were as follow:—

	Ft.	Ins.
Width inside the enclosing walls	211	6
Length	311	6
Depth from the top of the walls to the stringers in the floor of the dock	17	1¼
Depth from the level of ordinary high water to the top of the stringers	13	0
Depth from the level of ordinary low water to the top of the stringers	11	0

The maximum difference in the hydrostatic head, inside and outside the basin, existing during the progress of the construction of the basin, was 20ft. Detailed surveys and sections of the site were taken, so as to determine the precise contour of the rock, and of the mud over-lying it, which varied in thickness from 2ft. to 12ft. As the rock was unfitted for holding, or even for receiving sheet piles, except when the happened to strike a fissure, it was decided not to use the ordinary clay-puddle coffer-dam. The material selected for the walls of the basin was Santorin béton, composed of Santorin earth,—a volcanic product from the Greek island of Santorino,—and lime paste, in the proportion of 7 to 2, forming the hydraulic mortar; to this was added 7 parts of broken stone, the mixture being made into a conical heap and tempered by exposure in the open air for from one day to three days, when it was ready for use. Of this béton extensive wharves and moles had already been constructed at Trieste, Fiume, and Pola; and, as it had been found durable and efficient, was moderate in cost, and obtainable in any quantity, it was considered that no better material could be determined upon for the walls of the Pola basin. It might be mentioned that the largest blocks previously made were those at the mole of Fiume, which were 25ft. in vertical depth, 22ft. wide at the top, with a batter of 1 in 4 or 1 in 6, and 50ft. long. It was believed that, by adopting proper precautions, the mud which covered the rock bottom would form a suitable foundation for the walls of the basin, provided that a water-tight joint could be made at the bottom of the wall, for there could be no leakage or percolation through the béton, so long as it remained uncracked by unequal strains or settlements. It was, however, assumed that such cracks would occur, and that it would be necessary to provide for such a contingency. A wall of a plain rectangular section was decided upon, the thickness of which was determined with reference to the fact that the foundation consisted of greasy mud, lying at angles varying from 2° to 10°, which would render a slip possible. Joints were made across the wall, at intervals of from 40ft. to 90ft. in order to form weak places, which, being selected with reference to the nature of the bottom, would in all probability determine the location of any cracks that might occur. It was ascertained by calculations, based upon the data afforded from a knowledge of the contour of the rock bed and the mud bottom, that no crack could exceed 6in. as a maximum, and the ends of the blocks marked the localities where the settlements would probably take place. To check the passage of the water through the wall at these points, as well as to prevent the blocks from moving laterally upon one another, a rectangular post, 18in. by 24in., was inserted vertically in each of the joints, reaching from the upper surface of the block, through the mud, to the rock bottom below. These posts projected 12in. into each block of béton. Subsequent experience proved that this device was thoroughly efficient, the largest crack, which had a maximum width of 5½in., not admitting any water. The thickness of the walls varied from 15ft. to 20ft. and 26ft. The floating dock entrance was placed on the north side, and was adapted for an iron caisson to close it. This entrance was 120ft. wide in the clear, but the caisson measured 128ft. along the top line. The pump well was situated in the south-west corner of the basin. Great care was taken to make the stage piles stand vertically, as they were to remain permanently in the walls. The vertical diagonal bracing between the piles was removed as the béton was filled in. The enclosing sheet piles were carefully squared, so as to obtain perfectly true faces, for the purpose of obtaining tight joints, and to give the béton walls, of which the sheet piles formed the moulds, a fair surface. To facilitate the operation of driving the piles in line a machine was specially devised by the author, and termed by him a "spider." This consisted of two horizontal timbers, 35ft. long, placed parallel to each other and kept 12in. apart (12in. being the thickness of the sheet piling) by distance pieces. From the forward end of these timbers, two other timbers, also 12in. apart, sloped backwards and upwards, while at about 8ft. from the same end an oak block was passed between and bolted to the horizontal timbers, and this also sloped backwards and upwards, until it intersected the other two raking pieces before described and was bolted to them. This frame was hung by two vertical rods of wood to the staging above, and was free to swing to and fro; ropes and tackle were attached at the rear end, by which the frame could be moved in any desired direction, while, by a strong hawser fixed to the forward end, the jaws, formed by the horizontal timbers and the raking pieces, were made to embrace closely a short length of sheet piling already driven, the machine being hauled up so taut by the hawser that the raking oak block pressed against the face of the pile. The distance at which the "spider" was suspended from the staging was such, that the end of a pile about to be driven was engaged in the guide formed by it before its vertical position was affected by its tendency to float. When it was in operation the hawser at the forward end was hauled tight, and the end of the pile, pressing against the guide, extended the rope sufficiently to force the "spider" back, and permit the pile to pass and be driven in its exact position. It was found by experience, that with this machine at least double the amount of work could be done, and all the piles were kept exactly in their proper position. When the sides of the enclosure for one block had been completed, and

the cross dams and the vertical timber joint before described had been put in, the section was bolted together above the level of the béton work. and the operation of filling in was commenced, the average time required for this being two weeks. After the walls had been finished, the tie bolts clamping the sheet piles against the sides of the blocks were gradually loosened, to enable the former to settle freely, and to compress the mud from below. At the same time the interior rubble wall was built upon the top of the béton, to a level above high water, to form a dam. The sheet piles were subsequently cut off by a circular saw, and the exposed ends were covered by an external sloping embankment, or apron, of broken stone and sand. The principal internal filling of the basin, having been completed as the previous work progressed, as well as a temporary clay-puddled cofferdam closing the opening for the iron caisson, the pumping machinery was erected, and on the 2nd of February, 1859, the operation of emptying the basin was commenced. As was anticipated, the butt joints between the béton blocks were found to open, more or less, according to the character of the mud on which they stood, and the contour of the rock bed, but in no case did the timber joints fail. After the maximum settlement had developed itself, the cracks were carefully cleaned out, and filled with masonry to the depth of 1ft. from the face of the wall, and tubes or pipes were inserted in the wall, for conveying away any slight leakage that might escape without washing away the fresh mortar. Where a crack or joint appeared open on the external side of the béton walls, a pad, secured to a plank or timber, was firmly braced against it, until it was tight enough to prevent the escape of fine mortar or cement. The openings or cracks were then filled with thin grout, injected through a tube, under a head of about 10ft. above the wall. As soon as the basin was emptied, the work of laying the floor was commenced. This consisted of thirty rows of foundation piles, capped with timber 1ft. square, bedded in 6in. of béton. Upon the top of the piles was fastened close planking 6in. thick, and over this was laid the masonry, forming and completing nine lines of stringers, varying from 8ft. to 12ft. in width, to receive the bottom of the dock when grounded. The space of several hundred feet between the southern end of the basin and the island (Scoglio d'Olivie) was filled in, and two sets of railways, resting on pile foundations, were laid.

The caisson for closing the opening to the basin was built by the Messrs. Rennie, of London, and was found to answer its purpose completely.

At the meeting of this society on Tuesday the 7th ult., Mr. Charles B. Vignoles, F.R.S., President, in the chair, eighteen candidates were balloted for and declared to be duly elected, including three members, viz.:—Mr. Edward Dangerfield, District Engineer, Nagpore Branch, G.I.P. Railway; Mr. John Imray, M.A., Westminster; and Mr. John Pendlebury, Officiating District Engineer, Scinde, Punjaub and Delhi Railway, Umballa. Fifteen gentlemen were elected Associates, viz:—Mr. William Barber, Buckingham Palace Road; Mr. James Alston Carfrae, Stud. Inst. C.E., Wimbledon Common; Lieut. John James Curling, R.E., Stanhope Gardens; Mr. Francis Dawson, Deputy Director of Roads, Kingston, Jamaica; Mr. Joseph Emerson Dowson, Westminster; Mr. James Eldridge, Engineer to the Richmond Gas Company; Mr. Thomas Robert Gainsford, Stud. Inst. C.E., Birley Collieries, near Sheffield; Mr. John Edward Hilton, Assistant Engineer, P.W.D., India; Lieut. Col. William Robert Houghton, B.S.C., Executive Engineer, P.W.D., Nassick, India; Mr. George Henry List, Assistant Engineer, Oude and Rohilkund Railway, Benares; Mr. James Joseph Meagher, Superintendent of Public Works, Trinidad; Mr. Edward Rosenbusch, Engineer and General Superintendent to the Mediterranean Telegraph Extension Company; Mr. William Shield, Stud. Inst. C.E., Westminster; Mr. Louis Sterne, Westminster; and Mr. John Evelyn Williams, Chief Assistant to the Resident Engineer of the Hull Dock Company.

A report was brought up from the Council stating that, under the provisions of Sect. IV. of the by-laws, the following candidates had been admitted Students of the Institution since the last announcement:—Messrs. Thomas Holmes Blakesley, Oswald Brown, Oliver Fry, Edward Pontifex Harrison, William Russell, Frederick Valentine, and James William Wardle.

ON PHONIC COAST FOG-SIGNALS.

By Mr. A. Beazeley, M. Inst. C.E.

The coast of these islands being liable to fogs and mists, it was surprising that the subject of fog-signals, for the guidance and warning of the mariner under such circumstances, should have received so little attention; and beyond an occasional notice or a brief suggestion among scientific journals, there were no traces of systematic research and experiment. It was by some supposed, that great power and long range of sound were not essential to fog-signals, inasmuch as it was said fogs usually occurred in comparatively calm weather. This, however, was not the case, so far at least as regarded the coasts of Great Britain; for in the years 1868-69, fogs prevailed on the Yorkshire coast fifty-one times, at the entrance of the Bristol Channel one hundred and twenty-five times, and near Holyhead one hundred and seventeen times, with a total duration of 254$\frac{3}{4}$, 713$\frac{3}{4}$, and 698$\frac{1}{2}$ hours respectively; when the strongest winds were from the seaward, and varied in force from a mean of 4·55 and a maximum of 8 on the eastern coast, to a mean of 4·47 and a maximum of 9 on the western coast. But even where fogs were not usually attended by high winds, the necessity of power and range in fog-signals was in no way diminished; for a heavy snow-storm, or thick driving sleet and rain, which often accompanied a gale of wind, were quite as blinding and bewildering as the densest fog.

In 1863, a Committee of the British Association memorialized the President of the Board of Trade, with a view to induce him to institute a connected series of experiments as to the effect of fog upon various sounds. It was then shown, that the laws which governed the action of fogs in deadening sound were at present so imperfectly understood, that such a thorough and scientific enquiry was much to be desired, and was, in fact, essential to any real addition to the knowledge of the subject; without which, all investigations of isolated cases were little better than a vague groping in the dark. It was also pointed out that experiments during clear weather could not be accepted as affording satisfactory evidence of the value of any signal during fog.

The general tendency of fog to intercept or modify sound in its passage through the air, and the absence of reliable data as to the precise conditions which affected or varied the intensity of its action in this respect, had led to the suggestion whether water might not be employed as a medium for the transmission of fog-signals. The experiments of M. Colladon on the Lake of Geneva in 1826 were referred to, as well as the recommendations made in 1851 by Mr. Babbage to the United States lighthouse board, and Professor Hennessy's views on the same subject.

It was stated that the instruments in use for fog-signals were gongs, bells, guns, whistles, and trumpet—the two latter sounded either by steam or by condensed air—and a detailed description was given of these several appliances—whether in use or proposed—and of the experiments that had been tried to ascertain their efficacy.

In conclusion it was remarked that upon a review of the various fog-signals which had been mentioned, it was found that the whistle and the trumpet stood out prominently as regarded power and manageableness. Guns, besides their heavy working expenses, had the disadvantage of requiring a longer interval between the signals, and of entailing continuous work upon the attendant. It appeared, therefore, that it was to the improvement and the augmentation of power of the two former, that a more efficient instrument must at present be chiefly looked for. Whatever might be the fog-signal adopted in practice, power of sound and certainty of action were indispensable conditions. Better, it had been said, no signal at all, than one that could not be relied upon; and, undoubtedly, if the mariner was led to expect a signal at a certain place, and at a sufficient range to ensure time to act upon its warning, it ought to be so heard with unfailing certainty. Among existing signals there were some which, in ordinary fog and moderate weather, would fulfil these requirement; but it was doubtful how far they would act to windward against a heavy gale. The howling of the wind, the groaning and creaking of the hull and spars, the shock and roar and thunder of the sea, the drenching, blinding spray, the fierce blast, the thick mist—those were the antagonists against which the fog-signal would have to try its powers; and powerful indeed must be its voice, if it afforded in time a friendly warning.

There was another point with respect to fog-signals, where in connection with a lighthouse, which ought not to be overlooked; namely, the importance of making the character of the sounds, and their duration and intervals, correspond with the character of the light. The fixed light might be denoted by continuous sound, or better by a quick succession of sounds; the revolving and the flashing light by corresponding blasts; and coloured beams alternately with white light, by a lower and a higher note alternating in a similar manner.

One difficulty in the way of employing, at rock lighthouses, any fog-signal but a bell, or such other instrument as could be sounded by the application of simple clockwork, was the unsuitableness of such buildings for the reception and working of a steam or caloric engine, and the severe labour which would be entailed upon the keepers by the use of powerful machinery worked by hand. But the author still entertained the opinion, which he formed sixteen years ago, that the vast dynamical power afforded by the rise and fall of the tide would yet be utilised and applied to the compression of air for the purposes of fog-signals at such stations.

DESCRIPTION OF A WROUGHT IRON PIER AT CLEVEDON, SOMERSET.

By Mr. John Wm. Grover, M. Inst. C.E.

In this communication the author stated that the act for constructing a pier at Clevedon was obtained in the session 1863-4, but little was done upon the ground till the spring of 1868, which was singularly boisterous and unpropitious. The works were virtually completed at the end of the same year, and had since stood well, without material damage. The coast at Somersetshire at this spot was composed of dark cliffs of magnesian and mountain limestone, of which large fragments were scattered about the beach, the spaces between them being filled with soft mud. The site selected for the works was tolerably free from these obstructions, being a thin promontory of rock, level from right to left, and dipping seawards at an angle of 12° to 8°. Beyond this came mud 13ft. deep, upon boulders and clay. At the head, a ridge of sand, 2ft. deep, covered a bed of hard red clay, giving a tolerable bottom. The chief difficulty was however, the great rise and fall of the tide, viz., 45ft. at springs. As the Bristol Channel was only 9 miles across at this point, the water acquired the velocity of a mill-race on the ebb, or 5½ miles an hour. Clevedon was also exposed to high seas from the south-west. The structure comprised, first, an approach of masonry, 20ft. wide and 180ft. long, with a falling gradient of 1 in 10. Secondly, the body of the pier was formed of eight spans of 100ft. each, supported upon piers of Barlow rail piles, spreading to a wide base at the foot, and clustered at the top. From below the girders, arched ribs of Barlow rails, were connected to the vertical piles. The main girders of the structure were continuous, 3ft. 6in. deep and 800ft. long, the flanges being 1ft. 6in. wide, and all of wrought iron. The Barlow rails of the piles weighed 80lb. per yard each; they were riveted back to back, and were filled with a preparation of coal tar. The main girders were placed 16ft. 6in. apart; the seats, which were continuous, rested upon the top flanges, and the pier at the parapets was nearly 19ft. wide. The floor was laid with close planking 3in. thick, which ran longitudinally, and presented, with the camber of 3in. in the middle, an appearance like a ship's deck. The sides or parapets were close boarded. Below low water mark the Barlow rails were discontinued, and the piles consisted of solid stems of wrought iron 5in. in diameter, screwed to depths varying from 7ft. to 17ft., with cast-iron screws 2ft. in diameter. The pier head was 50ft. long by 40ft. wide. From the ground line to the deck it was 68ft. high. There were five lower stages or landing-decks, 10ft. apart, connected by wide staircases. The head was composed of piles of Barlow rails weighing 70lb. per yard each, riveted back to back; they were connected together with rolled joists, and were strongly braced by diagonal ties. The length of the longest pile was 76ft., and the pier was accessible at low water of spring tides. One span was tested with a central load of 42 tons, when the deflection was 1¼in. in the centre. The weight of wrought iron employed was less than 370 tons, and of cast iron 7 tons. The cost of the works was under £10,000. The contractors for the pier were Hamilton's Windsor Bridge Ironworks Company, of Liverpool, and for the approaches Mr. Ambrose Oliver; the works being designed and carried out by Messrs. R. J. Ward, M. Inst. C.E., and the author.

DESCRIPTION OF VIADUCTS ACROSS THE ESTUARIES ON THE LINE OF THE CAMBRIAN RAILWAY.

By Mr. Henry Conybeare, M. Inst. C.E.

The coast line which this section of the Cambrian Railway followed for nearly 86 miles was indented by numerous estuaries, which were crossed by viaducts having an aggregate waterway of upwards of 5,000ft.; most of these estuaries were very shallow, and the line traversed them on timber staging; in all cases, however, the viaducts across the low-water channels were permanent constructions, with wrought-iron superstructures resting on cast-iron piers. The viaduct over the tidal water of the Dovey had an opening span of 35ft., on the principle first used by Mr. Brunlees, M. Inst. C.E., in the viaducts in Morecambe Bay. The channel was not more than 3ft. deep at low water of spring tides, and as it was important to complete the bridge as rapidly and as cheaply as possible, the author employed ordinary piled foundations, fixing a cast-iron splice at the top of each timber pile, and driving it with it, so that the whole length of the timber should be sunk in the bed of the channel. So placed, timber piles would last as long as cast iron; they afforded a much cheaper foundation, and one more rapidly executed than screw piling. A similar expedient was adopted in constructing the fenders for the opening span of the Barmouth viaduct. The construction of the viaduct over the estuary of the Mawddach, at Barmouth, presented some difficulties, owing to the peculiar character of the foundation, and to the extraordinary velocity of the current at certain times of the tide. This viaduct had a waterway of 2,600ft. The estuary extended about 10 miles inland, and at the point where the railway crossed it, was constricted to less than one-half its normal width, by the projection from Cader Idris of a craggy promontory, called Figle Fawr. The deeper water (54ft. at ordinary spring tides) was close to the northern shore, and the northern bank, which was of basalt, shelved down almost precipitously into deep water; beyond this the bed of the channel was of sand, constantly shifting and varying in depth from 2ft. to 8ft. Below the sand was a bed of compact gravel from 6ft. to 8ft. deep; and below this again a peat bog, to a depth not passed through in the preliminary borings. The piers next the northern bank were placed on shelving rock and were necessarily cast-iron cylinders. But the unknown depth of the peat under the other portions of the channel, rendered the employment of cylinders inapplicable for the remaining piers, and screw piles were consequently used. The bed of gravel over the peat was all that could be depended upon to carry the bridge, and as this was too thin to be loaded heavily, the spans were reduced to 40ft.; and in order to equalise the load on the piles, and to distribute it over a larger area, the six piles of each pier were arranged in two equilateral triangular groups of three each, the upper lengths of each group forming a tripod. The diameter of the screw discs was 3ft., and the load about 2½ tons on each square foot of their surface, which was about one-half their sustaining power; after the surface of the channel had been covered with stones, this bearing area was supplemented by discs of 4ft. and 4ft. 6in. in diameter, which were bolted on to the piles and rested on the stone work. To avoid weakening the crust of gravel on which the stability of the bridge depended, the screw discs of the piles were placed 8ft. up the piles. The inconvenience inseparable from this mode of construction, when applied in such an exposed situation was attributed to the fact, that the piles of which each pier was composed—though sufficiently strong collectively when the pier was complete, and all its constituent parts firmly braced together, to withstand any stress of weather—had little individual strength when standing singly, or remaining unbraced, while the pier was in process of erection. The works, therefore, were somewhat delayed by piles being broken, and the staging for fixing them was swept away during heavy gales while the piers were in progress; but there was no instance of the slightest accident occurring to a pier after the bracing was once completed. Considerable difficulty was experienced in sinking the cylindrical piers owing to the velocity of the current, and the works had on one occasion to be suspended for some months. The opening span was 47ft. between the points of support, which was contracted to 36ft. by the fenders. The description of drawbridge to be employed in closing this opening was determined by the specialities of the foundation of the pier from which it was projected, which were on hard rock, shelving abruptly in a direction transverse to to the axis of the bridge. Hence a swing bridge was out of the question, and there only remained the telescope or sliding drawbridge. Of these there were two varieties, the under drawbridge and the over drawbridge. The former was devised and first employed by Mr. Brunlees, and was that adopted by the author for the opening span of the Dovey viaduct. The over drawbridge was less generally known, but one had been erected some years previously at Rhyl, and had worked satisfactorily. Irrespective of its general mechanical advantages, of working more easily, and of being lowered into position, instead of being lifted up into it and supported in it, the over drawbridge was much better adapted to the requirements of the Barmouth site, in respect to foundation, than the under drawbridge, for the latter required at least a second row of piles for the support of its sliding drawbridge, and as this had to be withdrawn between and within the supports of the contiguous bay, its width was either restricted, which in this case would have interfered with the footway alongside the railway bridge, or the intervals of the piles it slid between were unduly increased.

CHEMICAL SOCIETY.

ON THE DISTILLATION AND BOILING-POINT OF GLYCERINE

By Thomas Bolas.

It is well known that, when glycerine, subjected to the ordinary atmospheric pressure, is heated so much as to cause ebullition, it is more or less rapidly decomposed by repeated distillations. This decomposition may be, however, entirely prevented by a reduction of the pressure in the apparatus employed to 12·50 m.m. The boiling-point of glycerine was determined by effecting the distillation in a long-necked flask, having a supplementary neck attached at right angles to the principal one. In the principal neck, the thermometer was fixed by the aid of a caoutchouc cork, while the smaller neck was connected in a similar manner with a two-necked receiver. The glycerine, together with a few fragments of tobacco-pipe (this latter being required to prevent the bumping which would otherwise occur), being placed in the retortflask, the receiver was connected with a Sprengel's mercurial pump and a manometer, the caoutchouc joints being made air-tight with

glycerine in the usual way. Unless the glycerine distilled had been dehydrated by previous distillation in a vacuum, the first portion of the distillate consisted principally of water; afterwards, when the glycerine in a pure state came over, the temperature indicated by the thermometer was 179·5° C. At this time, the pressure on the liquid was 12·5 m.m., a pressure nearly corresponding to the tension of aqueous vapour at the temperature of the receiver. A determination of the carbon and hydrogen in the glycerine distilled as above was made; the oxidant employed being copper oxide, followed by oxygen gas, (1.), 0·4281 grm. CO_2 and 0·3439 grm. H_2O.

	Theory.		Found.
C_3	36	39·1	38·9
H_8	8	8·7	8·9
O_3	48	52·2	
	92	100·0	

Under a pressure of 50 m.m., glycerine distils without change at about 210° C. Glycerine, dehydrated by distillation, absorbs water from the atmosphere to the extent of about 50 per cent of its weight. The amount absorbed is, as might be expected, very variable.

THE ALLEN BOILER.

The following description is condensed from the *American Artisan*.

The accompanying engravings illustrate the peculiarities of construction that constitute the essential features of a new boiler made by the Allen engine-works, New York. It will be seen that the principle of tubes depending into the fire-box from the superior part of the boiler, as in the well-known Field boiler, is embraced in this; but in the present or Allen apparatus the internal tubes, upon which the Field boiler depends for its circulation, are wholly done away with, and the same end is secured by the simpler and less costly method of placing the depending tubes in a somewhat inclined position. This is plainly shown in Fig. 1, which is a longitudinal sectional view; while Fig. 2, a transverse section, shows the manner in which the tubes just mentioned are connected with the system of horizontal tubes, which, so to speak, form the central or main part of the boiler, and which, by suitably provided passages, connect with the cylindrical steam chest at the top.

The downwardly-extending tubes slant backward from the front of the furnace at an angle of about twenty degrees, their length increasing as they recede from the fire-box. Each longitudinal series of these tubes depends from a horizontal tube above. The horizontal tubes are arranged in the same plane, and each is connected by a short tube with the steam chest, which last is, of course, fitted with the usual and necessary appliances of a steam boiler. The short tubes, it may be mentioned, have their ends secured in the steam chest and horizontal tubes respectively by means of right and left hand screw-nipples. The hanging tubes are somewhat "staggered," to insure the more efficient action of the furnace-heat upon them, and their rearmost transverse set or series is connected at bottom by the feed-pipe shown near the lower left hand corner of Fig. 1. Another feature of these hanging or dependent tubes deserves notice: each is furnished in its lower end with a screw-plug, by removing which, sediment—should such collect in the tubes—may be readily removed. For a somewhat analogous purpose, the front end of each of the horizontal tubes is furnished with a detachable hand-hole plate. The hot gaseous products of combustion from the fire-box pass upward within the brick casing surrounding the boiler to superheat the steam, and thence backward among the inclined tubes. To insure the proper distribution of the hot currents from the fire-box, that part of the furnace back of the fire-box is furnished with two deflecting walls, represented in Fig. 1, and, after passing which, the gases make their exit, as indicated by the arrow. As previously intimated, the newly applied principle that characterises this boiler is that of circulation in inclined tubes. No internal tube is used; but, by inclining the tubes at an angle of twenty degress from the vertical, a circulation is obtained which it is said has never been equalled. The action may be plainly shown in a glass tube placed at that angle and exposed to intense heat. The water is seen to be circulating with great velocity, but the steam, however rapidly generated, has no tendency to drive the water out of the tube. The steam instantly springs from every point where it is formed, to the upper side of the tube, where it maintains a separate channel, rushing upward with no water before it.

FIG. 1.

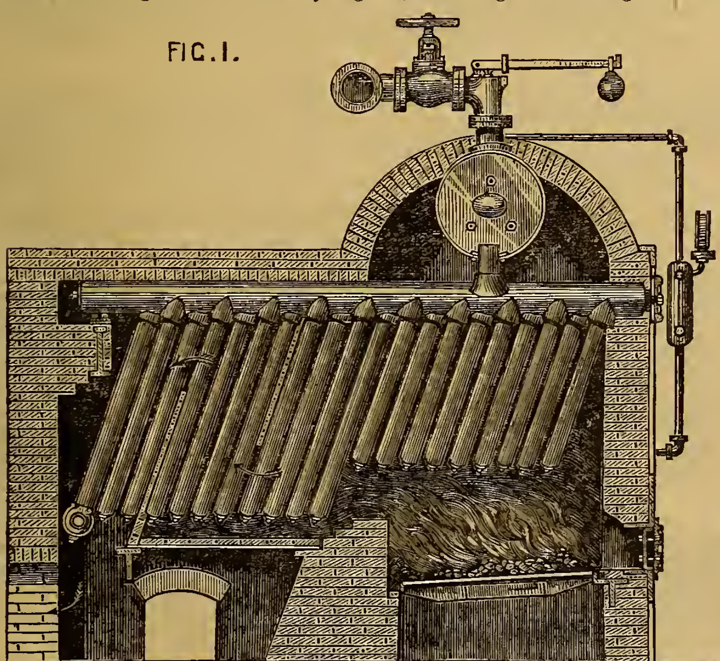
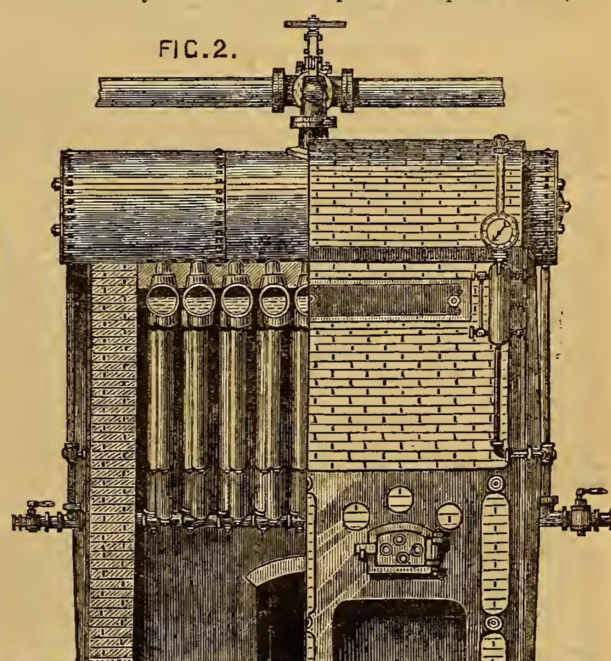


FIG. 2.



REVIEWS AND NOTICES OF NEW BOOKS.

Drawing for Machinists and Engineers. By E. A. Davidson. London and New York: Cassell, Petter and Galpin.

This work is one of a series of Cassell's Technical Manuals, which that enterprising firm have published at a price suited to the means of those for whom their information is intended. This treatise begins at the beginning; the first chapter giving a description of drawing boards, T squares, set squares, paper and pencils. As regards stretching the paper, by-the-bye, the directions are either scarcely lucid enough or not very good. The plan recommended of making holes through the paper to let out the air is possibly suggested by the treatment the skin of the author's hands have experienced when blistered after a hard days' work, but with a porous material like paper it is inapplicable. The arrangement of the various subjects upon which the work treats is very good, and the reader may consider each chapter as a separate lesson, which when mastered, facilitates the comprehension of the next. By this means the mechanic is led up from the most elementary details of mechanical drawing, to master the intricacies necessary for correctly delineating steam engines, pumping machinery, tools, and various other machines, numerous illustrations of which are scattered throughout the work. Considering the number of illustrations, and the amount of information contained in this book, Messrs. Cassell deserve great praise for publishing it at a price available for every mechanic.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Irish Fisheries.—The great success which has attended the present fleet of 200 vessels, representing a money value at Kinsale of upwards of £60,000, is inducing a great many people interested in the east coast of England fisheries to turn their attention to Ireland, at a period of the year when little employment exists on their own coasts, and as large numbers of boats are preparing to engage in the Kinsale fisheries, it is fully anticipated that the fishing fleet for the ensuing season will number upwards of 300 boats.—*Food Journal.*

A barbed nail is coming into use in America. Its advantages are obvious, for once driven in it will keep its hold as long as the wood around it remains solid. Its actual cost is little more than that of the common nail, and as a small barbed nail answers as well as a larger nail of the ordinary kind, it is stated to be considerably cheaper to use.

At a meeting of the Liverpool Chamber of Commerce on the 1st ult., a resolution was adopted approving the principle of a general survey of steam and sailing vessels, whether carrying passengers or not, and expressing the opinion that such survey should be applied equally to vessels sailing from the United Kingdom, whether under the British or foreign flag, and that such a system of survey should form part of the Merchant Shipping Code, instead of being made the subject of a private bill.

The borax deposits in Nevada are attracting considerable attention. It is stated that they are thickly distributed over an area of 100,000 acres; also that a New York house is about to erect works, under lease, on one of the deposits.

The *New York Herald* publishes the following telegram:—"Kingston, Jamaica, February 22.—A terrific fire broke out on Sunday night last on the Penzance estate, in the parish of Clarendon, the property of Lord Penrhyn. The boiling and curing houses were consumed, with 32 hogsheads of sugar ready for shipment. It is believed that the plantation was fired by a negro labourer in revenge for the overseer complaining of the instability of a fence the negro was employed in making. The Penzance estate is the finest in Jamaica, yielding two hogsheads of sugar to the acre of canes. If the boiling houses had not been consumed the crop gathered would have amounted to 400 hogsheads. This is the second plantation burned in the same parish within a fortnight. The sugar crop of Jamaica this year will be unusually large in every parish. The probable yield of the island is estimated at 40,000 hogsheads. Last year it was estimated at only 30,000."

NAVAL ENGINEERING.

The "Stevens Battery," so long building at Hoboken, New Jersey, will be ready for launching in June. This powerful war vessel is 410ft. long, 6,000 tons burthen, has engines of 5,000-h.p., and draws 22½ft., the hull being but 2ft. above the water line. She is to have two 20in. guns in a turret. Her armour is 10in. thick, and composed of 2in. wrought plates. She is built by a fund furnished by the late Edwin A. Stevens, of New Jersey.

Thirteen hundred marine torpedoes are in course of delivery at the Royal Arsenal' Woolwich, by Messrs. Spencelaigh and Archer, of Rochester, under a contract with the War Department, and are now being tested by hydraulic pressure as they arrive on the wharf. The 1,300 will consist of 500 of the largest size, each calculated to contain 500lbs. of gun cotton; 300 for 250lbs.; and 500 for 100lbs. Experiments have been made by the Royal Engineers with about 50 of these torpedoes, which are fired by electric wire from the shore or friendly vessels, and the result has been their adoption for the service. When the whole are delivered at Woolwich, they will be distributed to the naval authorities at the various seaports at home and abroad.

MILITARY ENGINEERING.

A large and distinguished party of officers, scientific men, and others assembled at the proof butts in the Government marshes, Royal Arsenal, Woolwich, on the 8th ult, to witness a trial of the new pattern Moncrieff gun-carriage for the 7in. breech-loading gun. Four rounds were fired with perfect success. Capt. Moncrieff worked the elevator himself, and the recoil each time brought down the gun under cover to the loading position with great exactitude. The new gun-carriage for the 7in. breech-loading gun is estimated to cost about £90.

TELEGRAPHIC ENGINEERING.

The Great Northern Extension Telegraph Company have chartered the steamer *Africa*, of about 2,500 tons, for the purpose of conveying the section of the submarine cable to be laid from Vladiwastok (Possiette) to Nagasaki, while the *Great Northern*, will take on board the section to connect Nagasaki and Shanghai, about 1,200 miles of cable in all. It is expected that these vessels will be despatched about the 15th inst *via* Suez Canal, calling at Singapore and Hong Kong, *en route*. Under favourable circumstances, the cable will be laid down and communication established about the 15th of July. The land lines through Russia to Vladiwastok are now in operation, thus affording a direct chain of communication from London to Shanghai. This company are also laying a cable from Shanghai to Hong Kong, which will probably be completed on the turn of the monsoon. The Telegraph Construction Company, under contract to the China Submarine Company, have despatched vessels with a cable to connect Singapore and Hong Kong, and this line will, barring accidents, be completed this month. The cable to connect Australia and Java will also be despatched in a few months. The project, started in Hong Kong, for connecting Bangkirk, Saigon, Manilla, and Hong Kong, the land lines which were last year despatched to Singapore, is, likely to be carried out, either on its original footing, or by an amalgamation with another company.

STEAMSHIPPING.

The Hon. J. Vogel, Colonial Treasurer and Postmaster-General of New Zealand, was a passenger by the Royal Mail steamer *Russia*, which arrived at Liverpool on the 24th ult from New York. In America Mr. Vogel concluded with Mr. W. H. Webb, the well-known shipowner and builder, of New York, a contract for the running of a 28-day mail service from New Zealand to San Francisco, touching at a port in the Hawaiian or Sandwich group. Steamers of over 2,000 tons burden are to be used, and the line will be in all respects a permanent replacement of the merely temporary one which has been running so successfully for the last 12 months.

SHIPBUILDING.

Messrs. Jones Brothers and Co. have arranged to build an iron steamer capable of carrying 750 tons of ore on a 14ft. draught, and intended to be employed between Whitehaven and Barrow, and Newport and Cardiff.

We understand that Messrs. Scott and Co. have, in addition to a 1000 ton steamer, contracted for two others, of 600 tons each, for the Continental trade. The engines of the two latter, of 100-h.p. each, will be furnished by the Greenock Foundry Company.

We understand that the Clyde Shipping Company have contracted with Messrs. Lawrie and Co., Whiteinch for the building of a large screw steamer, to be employed in the Cork and Waterford trade. Messrs. Robert Shankland and Co. have likewise contracted with Messrs. Barclay and Curle for the construction of an iron ship to register between 1,400 and 1,500 tons, and to be employed in the East India trade.

On the 25th February, the screw-steamer *Hecla*, forming one of Messrs. Burns and M'Iver's line, from Liverpool, arrived at the Tail of the Bank, and subsequently proceeded to Glasgow to receive an overhaul.

LAUNCHES.

On the 22nd ult., Messrs. Wigham Richardson and Co., launched from their Walker shipbuilding yard a small steamer of 50-h.p., for the passenger trade among the fiords of Norway. She was christened by Frln. Katrina Meidell of Bergen, the *Vidar*, after the son of Odin; and as soon as her engines are fitted she will proceed to Norway.

The fine new iron three-decked steamship *Sun Foo* was launched on the 23rd ult., by Messrs. Alexander Stephen and Sons, from their new works at Linthouse. The vessel has been built for a London firm, is 1,500 tons, highest class at Lloyd's 100A, and is to be employed in the China and Eastern trade. The ceremony of naming was performed by Miss Isabella Bain, of Edinburgh.

On the 22nd February, there was launched, from the shipyard of Messrs. J. and G. Thomson, at Govan, a screw steamship, of 1,468 tons, and 200-h.p., for Messrs. James Currie and Co., Leith, and intended for their continental trade. The *Iceland* was named by Miss Pauline, daughter of the commander.

There was launched on the 22nd February, from the building yard of Messrs. Heuderson, Coulhorn and Co., at Renfrew, a beautiful new iron screw-steamer of about 700 tons burden, which has been bought by Mr. Theodor Hertz, of this city, for the Baltic trade. This steamer has very fine lines, and is furnished with an awning deck, and expected to combine great carrying power with good speed. She is also to be engined by the builders with their improved compound engines, of 90-h.p. nominal, and will be fitted up internally in a superior style, embracing all modern comforts and conveniences for a limited number of passengers. She was gracefully named the *Louise*, when leaving the ways, by Mrs. Coulborn of Renfrew.

A new iron dredger Hopper steamer, of 250 tons burthen, built and engined by W. Simons and Co., was lately launched from the London Works, Renfrew. It has been built to the order of Messrs. M'Clean and Styleman, C.E., for Barrow-on-Furness, and is duplicate in arrangement to the twelve similar steamers constructed by this firm for the Clyde Trust, the Government docks at Carlingford, and elsewhere.

On the 28th February, the splendid new screw-steamer *Graf Bismark*, recently launched by Messrs. Caird and Co., Greenock, for the North German Lloyd's pioneer fleet, from Bremen to the West Indies *via* Southampton, proceeded on a preliminary trip previous to being despatched to Germany. The *Graf Bismark* is one of three steam ships which have just been completed by Messrs. Caird, for the West India trade, the other two being named *Koenig Wilhelm I.* and *Kronprinz Freidrich Wilhelm*. They are all of similar dimensions—viz., 300ft. long, 39ft. breadth of beam, aud 33ft. depth of hold. Their tonnage is 2,400 tons, and they are propelled by engines of 300-h.p., constructed by Messrs. Caird and Co. The accommodation provided for passengers is of a very superior description. The main saloons are remarkable for the elegance with which they are fitted up, every necessary for the comfort of travellers being liberally provided. The state rooms are large and well ventilated, while the arrangements on deck are most complete. Provision has been made for 120 first-class passengers, 60 second-class, and between 500 and 600 emigrants. The engines of the *Graf Bismark* worked at the trial with remarkable smoothness, and a speed of twelve and a-half knots was obtained under easy steam. The new route proposed is from Bremen, calling at Southampton to Colon, thence to Savanilla, Porto Cabello, and La Guayra returning *via* St. Thomas.

On the 28th February, a very fine new screw steamer, 370ft. in length, was launched from the building yard of Messrs. Robert Steele and Co., Greenock. She was named the *Sarmatian* by Miss Eliza Allan, 2, Park Gardens, Glasgow, and is intended to form one of Messrs. Allan's Canadian Mail Line of steamers, to ply between Liverpool and Montreal. She is to be propelled by powerful engines, with high and low-pressure cylinders, made by Messrs. Macnab and Co., of Greenock. The *Sarmatian* has been fitted with all modern improvements in hull and machinery, and will have splendid accommodation for about 100 cabin passengers, and for a large number in the steerage.

On the 28th February, Messrs. A. M'Millan and Son launched for the Submarine Telegraph Company, a substantially constructed paddle steamer, intended to be employed in the laying and repairing of coast telegraph cables. The vessel measures 160ft. × 25ft. × 13½ft., and has been named the *Lady Carmichael*.

On the 7th ult. Messrs. John Elder and Co. launched from their shipbuilding yard, at Fairfield, Govan, an iron screw-steamship of 2,700 tons register and 400 H.P. nominal, for the Stoomvaart Nederland Co., the first of four steamships which the builders have in hand for the same company. The vessel has been designed and constructed for that company's service between Holland and Java *via* the Suez Canal, and is of the following dimensions:—Length between perpendiculars, 320ft.; breadth, 39ft.; depth moulded, 31ft. In the equipment of the ship the latest improvements have been introduced, and nothing appears to be overlooked which will tend to the success of the vessel, and the passenger accommodation and fittings are of a high class of workmanship and finish. Accommodation has been provided for one hundred first-class, fifty second-class, and a few third-class passengers. She has great carrying capacity, with light draught of water. The engines, which are being supplied by the same firm, are upon their compound principle, with all recent improvements. On leaving the ways the ship was gracefully named the *Willem III.* by Mrs Vieboff, wife of Mr. Vichoff, one of the managing directors.

On the 19th ult. Messrs. Thos. Wingate and Co. launched from their building yard, at Whiteinch, a dredging machine of 500 tons B.M. and 70 H.P. Fitted with twin screws, she is adapted for dredging in 30ft. of water, and capable of lifting about 350 tons per hour, and is fitted with the latest improvements introduced by this firm. The Messrs. Wingate have on hand a duplicate dredger to the one just launched, also a screw hopper, all for Barrow-in-Furness, and built to the order of Messrs. M'Lean and Stileman, C.E., London, the engineers for the extensive improvements at present going on there.

On the 11th ult. Messrs. Aitken and Mansel launched from their shipbuilding yard, Whiteinch, a handsome screw vessel of 1,300 tons register, named the *Duna*. This vessel has been built to the order of Leith owners, and is intended for the East India trade. Machinery will be fitted by Messrs. T. M. Tennant and Co., Leith.

On the 6th ult. at high water, the *Pacific*, the second of the fleet of Ocean steamers for the Oceanic Steam Navigation Co., Liverpool, was launched from the shipbuilding yard of Messrs. Harland and Wolff of Balfast. The *Pacific* is 437ft. long, the breadth of beam being 41ft. Her gross register is 4,000 tons. She will be fitted out in Belfast with everything except the engines, which are to be supplied by Mandsley, Sons and Field, of Lambeth. The *Pacific* will be classed 20 years in red in Liverpool registry.

On the 9th ult. there was launched at Chatham dockyard the wooden vessel *Woodlark*. There was a large attendance of spectators, and the ceremony of christening was performed. Although the *Woodlark* is built of oak, a good deal of iron has been employed wherever found practicable. Iron stringer plates traverse the whole length of the ship, while iron has been used for the bulkheads, as well as for the upper deck beams. The result has been to increase the stiffness and rigidity of the hull, and, at the same time, to impart additional strength to the entire structure. The engines will drive double screws, the machinery being of 160 horse-power (nominal), the vessel being launched with the whole of her engines, boilers, and machinery fitted on board. The following are the leading dimensions of the *Woodlark*: Length between perpendiculars, 170ft.; extreme breadth, 29ft.; depth in hold, 12ft. 5in.; burden, 662 65·94 tons; mean draught of water, 9ft. 9in. Her armament will consist of one 6½ ton pivot muzzle-loading rifled gun and a couple of 40-pounders. She will be immediately docked to be coppered and brought forward for commission.

RAILWAYS.

The total amount of the bonds issued by the United States' Treasury to the various Pacific Railroad Companies stood at the close of January, 1871, at 64,618,832 dols. The interest account at the same date showed a loss to the United States of 8,293,092 dols.

The works of the Royal Sardinian Railway were resumed with vigour in November last, and the first section is expected to be opened this month.

A bill has been introduced in the present session of Parliament by the Somerset and Devon Company for an extension of the line from Evercreech to the Midland Railway at Bath, passing through the Mendip coal-field, *via* Radstock.

In September and October the Lytteltou and Christchurch Railway, in the province of Canterbury (New Zealand), earned £5,607 as compared with £4,227 in the two corresponding months of 1869. The Great Southern Railway of Canterbury earned in September and October £1,943, as compared with £1,114 in the two corresponding months of 1869. The substantial increase presented in the two months of 1870 speaks well for the resources and progress of the province. The reserves of the Great Southern line are to be planted with trees, and rolling stock and other material required for railway extension are to be, as far as practicable, of Canterbury manufacture.

Mr. J. Fowler, the engineer of the Metropolitan District Railway, states that the works for the completion of the railway under Queen Victoria-street, and for the construction of the City station at the intersection of that street with Cannon-street, are now in full progress, and the vigorous prosecution of them by the contractors will insure their completion by the 1st of July next.

ACCIDENTS.

On the 6th ult a singular but rather alarming accident occurred upon the West Hartlepool and Stockton branch of the North-Eastern Railway. The consequences to the passengers were, however, confined to a severe fright. The accident occurred to the passenger train leaving Ferryhill Junction at 6 5 p.m. for Stockton and West Hartlepool, and after the division of the carriages at Norton Junction for these places the Stockton portion pursued its ourney southward; but when it arrived within a mile of its destination the connecting-rod on the near side of the engine, suddenly snapping, was driven completely through the side of the boiler, so rending it as to allow the whole of the boiling water and steam to escape with so loud a noise as greatly to alarm the passengers, who providentially escaped injury, as did also the driver and fireman, whose escape was really marvellous. The train, of course, was brought to an immediate stand and could not go further until a fresh engine was brought from Stockton, to which place a messenger was despatched for assistance.

DOCKS, HARBOURS, BRIDGES.

From the Darien Canal surveying expedition important intelligence has been received. Captain Selfridge, the commander of the expedition, writes from Paye, under date of the 13th of January, that he has discovered a route for the canal, the summit of which is but 300ft. above the ocean, and that the route begins near the mouth of the Atrato River.

The Gloucester and Berkeley Canal is to be lengthened two miles, and a new entrance, &c., made, at an outlay of about £150,000. Additional capital is to be raised, and £100,000 having been asked for, nearly £90,000 of it has been already taken up in and about Gloucester.

APPLIED CHEMISTRY.

Dr. Crace Calvert states that iron immersed for a few minutes in a solution of carbonate of potash or soda will not rust for years, through exposed continually in a damp atmosphere. It was believed long ago by soap and alkali merchants that the austic alkalies (soda and potash) protected iron and steel from rust, but that the components of these salts preserved the same property as they do in a caustic state now. It does not seem to matter whether the solution is made with fresh or sea water.—*Iron-mongers Journal.*

Dr. Hager states that the addition of ten drops of chloroform to 100 grms. of cod-liver oil render that fluid perfectly agreeable and palatable to take, without in the least impairing its good quality, or interfering with its effect on the human frame.

Zimmermann proposes to discover cotton in linen tissues by dipping the sample for eight or ten minutes into a mixture of two parts of nitric and three parts of sulphuric acids. If cotton be present, gun cotton, which can be extracted by a mixture of alcohol and ether, would be formed in this manner.

Professor Böttger prepares cement of diverse colours and great hardness by mixing various bases with soluble glass. Soluble soda glass of 33 deg. B. is to be thoroughly stirred and mixed with fine chalk, and the colouring matter well incorporated. In the course of six or eight hours a hard cement will set, which is capable of a great variety of uses. Böttger recommends the following colouring matters:—(1) Well sifted sulphide of antimony gives a black mass, which, after solidifying, can be polished with agate, and then possesses a fine metallic lustre; (2) fine iron dust, which gives a grey black cement; (3) zinc dust—this makes a grey mass, exceedingly hard, which, on polishing, exhibits a brilliant metallic lustre of zinc, so that broken or defective zinc castings can be mended and restored by a cement that might be called a cold zinc casting; it adheres firmly to metal, stone, and wood; (4) carbonate of copper gives a bright green cement; (5) sesqui-oxide of chromium gives a dark green cement; (6) Thenards' blue, a blue cement; (7) litharge, a yellow; (8) cinnabar, a bright red; (9) carmine, a voilet red. The soluble glass with fine chalk alone gives a white cement of great beauty and hardness. Sulphide of antimony and iron dust, in equal proportions, stirred in with soluble glass, afford an exceedingly firm, black cement; zinc dust and iron in equal proportions yield a hard, dark grey cement. As soluble glass can be kept on hand in liquid form, and the chalk and colouring matters are permanent and cheap, the coloured cements can be readily prepared when wanted, and the material can be kept in stock, ready for use, at little expense. Soluble glass is fast becoming a most important article of chemical production.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	74	0	0	,,	,,	,,
Tough cake and tile do.	72	0	0	,,	,,	0
Sheathing and sheets do.	75	0	0	77	0	,,
Bolts do.	77	0	0	,,	,,	,,
Bottoms do.	80	0	0	,,	,,	,,
Old do.	65	0	0	,,	,,	,,
Burra Burra do.	74	0	0	,,	,,	,,
Wire, per lb.	0	0	10	0	0	10½
Tubes do.	0	0	10½	0	0	10¾
BRASS.						
Sheets, per lb.	0	0	7¾	0	0	8
Wire do.	0	0	7½	0	0	7¾
Tubes do.	0	0	9½	0	0	10½
Yellow metal sheathing do.	0	0	6⅝	0	0	7¼
Sheets do.	0	0	6⅜	,,	,,	,,
SPELTER.						
Foreign on the spot, per ton.	18	0	0	18	5	0
Do. to arrive.	17	15	0	,,	,,	,,
ZINC.						
In sheets, per ton	23	10	0	24	0	0
TIN.						
English blocks, per ton.	130	0	0	,,	,,	,,
Do. bars (in barrels) do.	131	0	0	,,	,,	,,
Do. refined do.	134	0	0	,,	,,	,,
Banca do.	130	0	0	,,	,,	,,
Straits do.	129	0	0	130	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	6	6	1	8	6
IX. do. 1st quality do.	1	12	6	1	14	6
IC. do. 2nd quality do.	1	5	6	1	6	6
IX. do. 2nd quality do.	1	11	6	1	12	6
IC. Coke do.	1	2	6	1	4	0
IX. do. do.	1	8	6	1	10	0
Canada plates, per ton	13	10	0	14	10	0
Do. at works do.	13	0	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	5	0	,,	,,	,,
Do. to arrive do.	7	2	6	7	5	0
Nail rods do.	7	5	0	7	15	0
Do. Stafford in London do.	7	7	6	8	0	0
Bars do. do.	8	0	0	9	2	6
Hoops do. do.	8	15	0	9	5	0
Bars do. at works do.	7	15	0	8	0	0
Hoops do. do.	8	2	6	8	5	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	6
Bars, common, do.	6	10	0	,,	,,	,,
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	10	0	,,	,,	,,
Do. Swedish in London do.	,,	,,	,,	,,	,,	,,
To arrive do.	10	5	0	,,	,,	,,
Pig No. 1 in Clyde do.	2	12	0	3	0	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. Nos. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	10	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	,,	,,	,,
English spring do.	17	0	0	,,	,,	,,
Quicksilver, per bottle	11	0	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	10	0	,,	,,	,,
Ditto L.B. do.	18	10	0	18	12	6
Do. W.B. do.	19	10	0	,,	,,	,,
Do. sheet, do.	19	0	0	,,	,,	,,
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	21	0	0	,,	,,	,,
Spanish do.	18	0	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated February 15th, 1871.

378 A. Barton—Recording telegraph
379 H. Clause—Taps or valves
380 T. J. Smith—Gun carriages
381 S. Dawson—Steam valves
382 H. Hebden—Mules for spinning
383 J. Graddon—Glands and packing for piston rods of pumps
384 J. Graddon—Steam boilers
385 W. Goreham—Kilns for burning cement and lime
386 H. Bessemer—Repairing or restoring the lower parts of the linings and tuyeres of converting vessels employed for the produ tion of malleable iron, &c.
387 H. E. Mines and P. C. Evans—Improving combustion, &c.
388 J. H. Johnson—Bars, rails for railways, &c.
389 A. L., A. C., and W. Cochrane—Treating wool

Dated February 16th, 1871.

390 G. Angell—Steering vessels
391 W. P. Savage—Sails for ships
392 J. Macleod—Liquoring yarns
393 J. Mead—Recreation of children, &c.
394 S. F. Van Choate—Firearms
395 J. W. Beasley—Ball valve
396 W. T. Henley—Apparatus for hauling by ropes
397 J. Henderson—Chain pulleys
398 P. R. Hodge—Manufacture of certain textile fabrics
399 T. Lambert—Pianofortes
400 T. Jenning—Safety valve
401 J. Brown—Collars, &c.
402 D. Hanson—Apparatus for flanching, moulding, &c.
403 J. Reilly—Chairs
404 A. Barclay—Blast furnaces
405 W. Unwin—Self-acting break
406 J. Taylor—Doffing bobbins, &c.
407 J. W. Parker—Boring and drilling
408 R. Ford—Bird cages
409 Hon. J. T. Fitzmaurice—Breech loading guns
410 G. Haseltine—Machine for distributing type
411 J. O. Greenwood, D. Mills, and M. Pearson—Looms

Dated February 17th, 1871.

412 W. Tatters—Registering apparatus
413 G. M. Hammer—School furniture
414 B. C. Badham—Skates
415 J. R. Macarthur—Cotton gin
416 J. Horton—Screw propellers
417 E. Secl—Tuyeres
418 J. E. Wilson—Rolling stock
419 J. E. Wilson—Motive power
420 M. Wilson—Fire alarm
421 W. Pilkington—Traction engines, &c.
422 J. Bromilow—Furnaces
423 A. E. Fletcher—Measuring the rate of motion of a ship
424 A. Balme and A. B. Crossley—Punching plates for ships
425 A. Wyley—Firearms
426 A. W. Pocock—Liquid meters
427 D. Smith—Railway rail
428 W. E. Newton—Pen holders
429 W. E. Newton—Lamps
430 A. J. Parker—Printing presses
431 J. Gordon—Separating cotton fibre from the seed of the cotton plant

Dated February 18th, 1871.

432 G. Tweedy—Chairs or fastenings for the permanent way of railways
433 J. D. Larsen—Fastenings for rails and sleepers
434 J. Head and W. Thomson—Arrangements to render road steamers applicable for farming operations
435 J. J. Stevens—Fixing the points at junctions
436 H. Cannell—Boilers
437 J. H. Johnson—Illuminating gratings for roofs
438 H. R. Minns—Fastenings, &c.
439 H. Armistead, T. Tunstill, and T. Bannister—Looms
440 C. F. Collom—Cleaning metals, &c.
441 C. J. Cox—Sowing seed

Dated February 20th, 1871.

442 R. Ritchie—Skates

Dated February 21st, 1871.

443 G. Eveleign—Manufacture of gas
444 E. Brasier—Rubbing surface
445 C. J. Ball—Raising, &c., rock drills
446 W. E. Gedge—Extracting the tin from the shearings of tinned iron plates
447 S. Holmes—Optical instruments
448 T. West—Covers for dishes
449 J. H. Sams—Sowing machines
450 J. Jeffreys—Sun blinds
451 W. Buttery and J. Pashley—Reloading cartridges
452 G. Haseltine — Carburetting atmospheric air

Dated February 22nd, 1871.

453 E. W. Jobson—Ovens
454 A. Budenberg—Injectors
455 H. Lees—Ordnance
456 A. Budenberg—Steam engine indicators
457 J. A. Franklin and A. C. F. Franklin—Engines worked by steam
458 S. C. Lister—Looms
459 W. H. Glover and J. Hargreaves—Looms
460 F. Durand—Extracting the edible part of shrimps, &c.
461 B. Slater—Regulating the turning of gas cocks
462 W. Lancaster—Sizing machines
463 H. Saunders—Track clearers for railways
464 M. Henry—Bedsteads
465 A. B. Blackburn—Pens
466 F. Foster—Forming screws upon the necks of bottles
467 J. M. Napier—Balances
468 M. Macdermott and A. D. Williams—Boring holes
469 W. A. Telling and S. Johnson—Gas meters
470 T. J. Smith—Production of chlorine
471 G. Haseltine—Spectacles
472 G. Haseltine—Carburetting atmospheric air

Dated February 23rd, 1871.

473 J. Thomas—Slate ridges
474 R. Heyworth — Supplying water to wash basins
475 G. Haseltine—Gas burners
476 G. Haseltine—Combined knife and glass cutting instrument
477 G. Haseltine — Separating magnetic iron from sand, &c.
478 H. Crichley—Ranges
479 G. Clarke—Fire escapes
480 T. Whitehead—Combing wool
481 T. Atkinson—Steam cultivating machinery
482 F. C. Gautier—Looms
483 W. L. Wise—Ordnance
484 W. Morris—Regulating the supply of water
485 J. Tullis—Tubes for carrying yarn
486 A. Priest and W. Woolnough—Drilling land
487 J. R. Liston—Improved glove, &c.

Dated February 24th, 1871.

488 G. H. Ellis—Rails for railways
489 W. Jackson—Pumps, &c.
490 J. Lowthian — Water flushing apparatus
491 T. J. Smith—Nitrification of ammonia
492 E. E. Glaskin—Safety valves
493 W. Moscrop—Spinning, &c.
494 J. Macleod—Dyeing, &c., yarns
495 A. Barraclough—Dewing fabrics
496 G. and J. G. Ritchie—Weather protectors
497 A. E. Butler—Naves of wheels
498 J. H. Johnson—Pencils
499 J. Wilkinson—Grinding saws, &c.

Dated February 25th, 1871.

500 E. C. Stiles and J. F. Elsdon—Dressing millstones
501 G. Gore—Guiding the wheels of tramway cars, &c.
502 J. Scaife and T. C. Younger—Packing for pistons
503 W. Green—Bullets
504 F. Silas—Writing in ciphers
505 E. Boyes—Roasting coffee
506 J. P. Smith—Tools
507 J. M. Douglas—Oils
508 W. H. Brown and W. Lockwood—Cast steel tubes
509 T. Aveling—Road rollers
510 F. A. Paget—Malleable cast iron
511 F. A. Paget and J. W. Asher—Ice making, &c.
512 E. Rowland—Fire-bars
513 J. Jackson—Spades, &c.
514 A. Lloyd—Farinaceous food
515 C. Akin—Post cards
516 E. Wright—Applying brakes
517 A. Armour—Gas engine
518 G. Haseltine—Electrotyping

Dated February 27th, 1871.

519 C. Duff — Treatment of fibrous substances, &c.
520 A. A. Cochrane—Application of bituminous compositions
521 I. Jones—Steam boilers
522 W. Millard—Looms
523 A. Arnold—Imparting a continuous travelling motion to wire, &c.
524 I. Roberts—Retorts and kilns
525 S. W. Snowden and J. Moffatt—Safety valves
526 R. Fennelly—Preserving animal substances
527 J. Patterson—Beetling woven fabrics
528 G. Haseltine—Steam traps, &c.
529 J. Carver—Bobbin net, &c.
530 J. H. L. T. Pörtner—Sewing machines
531 A Guthrie and J. Stevenson—Motive power engines
532 J. H. Johnson—Gunpowder

Dated February 28th, 1871.

533 J. H. Johnson—Sand glass paper
534 S. Wilson—Braces
535 J. and W. Truswell—Heating air
536 R. and W. J. Griffiths—Screw propellers
537 T. P. B. Warren—Treatment of india rubber
538 S. Thomas and W. Guise—Needles, &c.
539 C. E. and C. R. Schwartz—Metal frames of purses
540 G. Haseltine—Photo electrotyping
541 J. Rennie—Furnaces

Dated March 1st, 1871.

542 J. and W. McNaught—Washing wool
543 A. A. Common—Automatic apparatus
544 G. W. Doeg—Rotary motion, &c.
545 J. Burman—Brushes, &c.
546 R. M. Marchant—Steam engines
547 J. A. Baxter—Railway brakes
548 W. Wright—Making roads, &c.
549 W. R. Lake—Regulating the pressure of steam
550 H. H. Wippell—School desks
551 E. P. Sherwood—Preparing clay

Dated March 2nd, 1871.

552 W. W. Smith—Anchors
553 T. H. Walsh—Signalling between the different parts of railway trains
554 T. R. H. Fisken—Windlasses
555 F. R. Wheeldon—Wheels
556 J. Bannehr—Gas
557 C. de Negri and E. Craddock—Expressing of oils
558 J. and J. Maxfield—Spoons, &c.
559 R. W. Boyd—Safety valve
560 R. H. Radford—Rolling rails, &c.
561 D. Payne—Printing machinery
562 F. D. Sutherland—Fastening for the covers of umbrellas
563 J. Betteley—Anchors
564 G. Buxton—Rails for railways
565 P. Penn-Gaskell—Cutting drains

Dated March 3rd, 1871.

566 W. E. Gedge—Feathers
567 R. and R. Bickerton—Harvesting machines
568 J. Briggs and J. Railey — Aerated waters
569 T. Rowatt—Lamps
570 J. B. Stoner—Suit for saving life in water
571 W. Rockliff—Reversing link motion
572 C. F. Cotterill—Attaching taps, &c.
573 H. Willatt, R. Gee, and J. Goss — Looped fabrics
574 H. Lindon—Metallic bands
575 R. Moore—Manufacture of sugar
576 J. Dunkley—Sewers
577 G. W. Carr G. Butterworth and J. Hamer—Printing felted fabrics
578 G. Haseltine—Shafting

Dated March 4th, 1871.

579 R. Turner—Preparing cotton
580 J. B. Bunyard—Portfolio stands
581 H. M. Kennard—Driving screw piles
582 H. M. Kennard—Bridges, &c.
583 M. P. Galloway—Tube cleaners
584 B. Hunt—Washing wool
585 M. and A. Paul—Ships' windlasses
586 J. Wilkes—Wheels, &c.
587 G. T. Bousfield—Lamp wicks
588 J. Head and J. R. Jefferies—Implements for cultivating land
589 J. C. Ramsden—Looms
590 E. Morgan—Measurement of fabrics
591 O. A. Ullithorne—Carriages used by invalids

Dated March 6th, 1871.

592 E. Davis—Railway chairs
593 W. Howarth—Looms
594 C. Stewart and R. Bond—Looms
595 A. Budenberg—Pumps
596 J. Horton—Gaseliers
597 G. Berwick—Preserving metallic surfaces
598 C. J. L. Leffler—Spiegel eisen
599 R. S. Newall—Breaking stones
600 D. B. Thompson—Distributing type
601 M. R. Maythorn—Phaetons, &c.
602 W. R. Lake—Safety valve

Dated March 7th, 1871.

603 J. E. Scott—Ships
604 J. H. Wrench—Slides for magic lanterns
605 A. Annandale—Pulp for making paper
606 J. Kent—Tightening the cords of window blinds
607 A. W. Gillman and S. Spencer—Treatment of beer, &c.
608 E. T. Hughes—Boxes, &c.
609 F. R. A. Glover—Hoisting, &c.
610 A. V. Newton—Arresting the motion of railway trains
611 R. S. Newall—Ropes, &c.

Dated March 8th, 1871.

612 E. Davies and E. Hutchinson—Hydraulic machines
613 C. Parkinson and R. H. Lloyd—Carding engines
614 J. Kent—Brushes
615 J. Somervell—Artificial leather
616 C. R. Western—Boxes for matches
617 R. Johnson—Steering ships
618 J. Hargreaves and W. Rostron—Prevention of accidents upon railways
619 W. G. Cannon—Gas cocks, &c.
620 J. Starley—Sewing machines
621 E. Wright—Indicating the number of persons travelling, &c.
622 B. J. Edwards—Photographic pictures

Dated March 9th, 1871.

623 J. F. M. Pollock—Bricks
624 T. Gibb and C. Gelstharp—Treating metallic solutions
625 J. Downes—Metallic hoops
626 J. Tenwick—Reaping machines
627 T. W. Dodde—Locomotive engines
628 J. Addie—Manufacture of iron
629 H. J. H. King—Feeding carding machines
630 J. A. Turner—Packing material
631 J. Whitaker, B. Lupton, and C. Catlow—Washing machines
632 J. Lodge—Artificial fuel
633 J. H. Johnson—Retaining, &c., umbrellas
934 C. Powell—Watches

Dated March 10th, 1871.

635 T. S. Blair—Reduction of iron ores
636 J. D. Larsen—Lamps
637 J. C. Botham—Pipes for the conveyance of sewage
638 G. H. Carter—Paddle wheels
639 T. Restell—Breech loading firearms
640 M. A. Sutherland—India rubber compound
641 A. M. Birchall—Preventing explosions to steam boilers
642 H. Vosper—Steam engines
643 R. Brough and C. Mace—Steam boilers
644 P. Kacuffer—Generation of steam
645 T. N. Kirkham, V. F. Ensom, and G. Spence—Scouring, &c.
646 T. Murphy—Rotary engines
647 D. Soutar—Hackling jute

10 HP HORIZONTAL ENGINE

BY

CHARLES POWIS & Co MILLWALL PIER

Fig. 1.

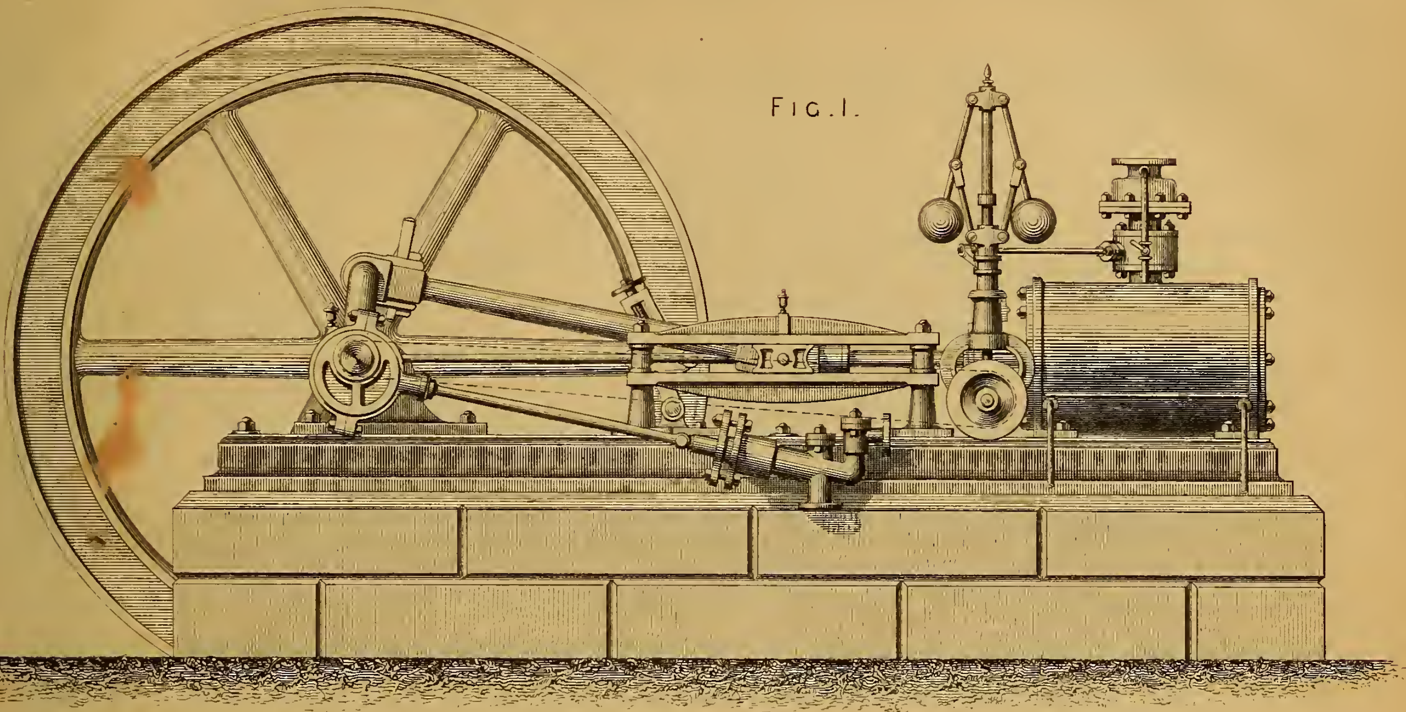


Fig. 3.

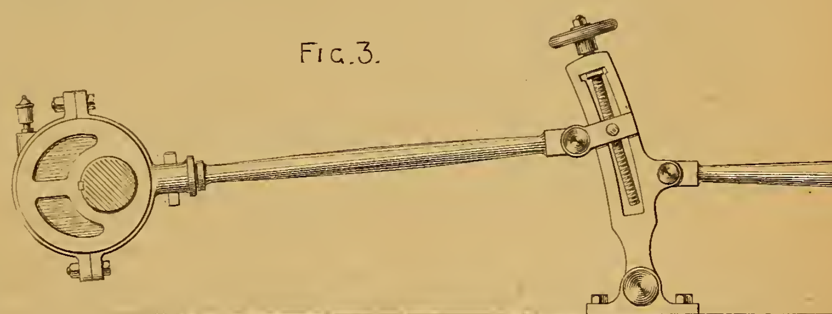
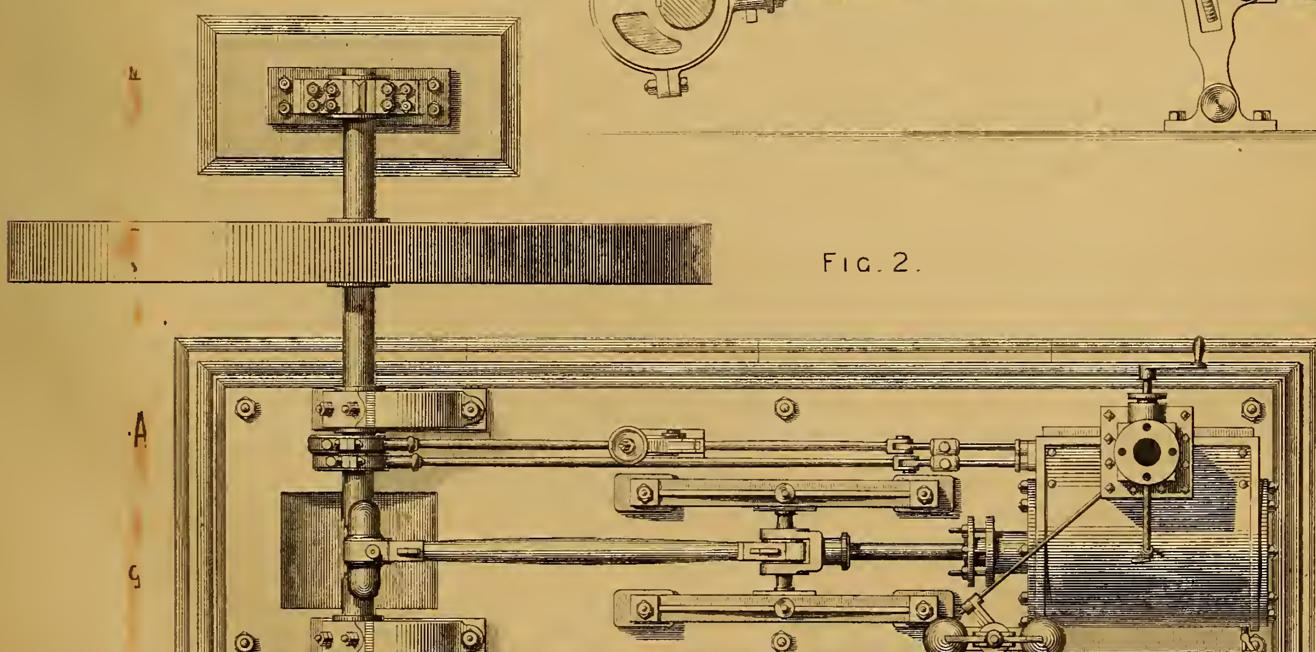


Fig. 2.



P. Soames, C.E. direx

Engraved by G.B. Smith

THE ARTIZAN.

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1st MAY, 1871.

HORIZONTAL ENGINE WITH VARIABLE EXPANSION GEAR.

By Messrs. C. Powis and Co., London.

(Illustrated by Plate 373).

Of the immense nnmber of stationary engines manufactured of late years in this conntry the vast majority of them have been of the horizontal type. Although many manufacturers and steam users apparently prefer engines with their cylinders placed vertically, either npright or inverted, from their fancied superiority in the wear of the piston and cylinder, they are in a decided minority, and, as we think, justly so. The idea that the weight of the piston acting upon the lower portion of the circumference of the cylinder would speedily canse it to assume an oval shape, has after a long series of years, been proved erroneons. In fact, it is too well known to be here insisted upon that the want of perfection in the adjnstment of parallel motions or guides in vertical cylinders, has been far more injnrious in this respect, than the comparatively unimportant wear occasioned by the weight of the piston. The horizontal arrangement is, moreover, more generally convenient for the positions in which an engine is reqnired to be placed, while at the same time it admits of easy access to all its working parts.

As regards the attainment of perfection in manufactnre, we have always considered that the horizontal engine is by far the most convenient, as the whole of the work when once set out may be performed by machinery. Thus the bed-plate when once fixed on the planing machine, may have the varions surfaces to carry the cylinder, guides, bearings, &c., all "trued up" without altering its position on the surface plate of the machine; and, therefore, these surfaces are not only far more likely to be correct than when done separately or by hand, but the expense of performing this most important part of engine making, is reduced as far as possible.

Assnming, therefore, that a horizontal engine is for most pnrposes the most convenient form, the qnestion arises, what is the best arrangement of such engine suitable for general purposes. Next to first-class workmanship, which, we may assume as indispensable, intending purchasers naturally look to economy. Of course, as we have jnst taken for granted, no one in their senses would expect to find economy by purchasing an engine, simply because the price is very low, as the expenses included in wear and tear, "breakdowns," and consequent stoppages throughont the works, would very soon pay the first cost of a good engine. Such persons have, therefore, but two things to consider, viz., the first cost of the engine, and the cost of fuel, attendance, &c., it will entail. Upon the subject of economy, we have freqnently fonnd somewhat erroneous ideas; many persons taking for granted, that the engine that consumes the smallest amount of fuel per indicated horse power, must be the most economical. Now, we do not of course mean to assert they are necessarily wrong in making snch an assumption, but we will endeavour to show they are not necessarily correct.

For this purpose, we will take the three well-known classes of engine, each worked by similar boilers at the same pressure, viz., those that are worked without any special means for expansion; those worked expansively; and condensing engines either single or compound. As regards these three classes, the first is the simplest, the cheapest, and the most extravagant of fnel; tho second is almost as simple, somewhat more expensive, but consumes far less fuel; while the condensing engine is considerably more complicated, and more costly, but in its consumption of fuel the most economical. From this, it is evident, that where the cost of fuel is so low as to make its consumption a matter of unimportance, the common high-pressure engine is the most suitable. In fact, we remember many years ago, when the system of donble valves was somewhat in its infancy, incurring considerable ridicule for recommending expansion gear to winding engines, where the coal could be obtained for nothing. This is, althongh to a less extent, the case in many of the coal districts, and as a natural consequence, we find steam nsers in those parts of the country contenting themselves with the cheapest engine that can be obtained. The converse of this situation is to be found where the cost of fuel is excessive. Thus, in the colonies where fuel—whether it be wood or coals, the economic valuc is generally eqnalised by the law of supply and demand—is very expensive, the first cost of an engine is of much less consequence than its ability to perform its work with a minimnm consumption of fuel. This is also true with regard to steam vessels, where, although the coals may be shipped at a moderate price, any quantity beyond that required by the most economical description of engine is, of course, so much tonnage deducted from that derived from freight of goods which might otherwise be carried. The engine shown in Plate 373, is intended to be employed where fuel is neither too cheap to induce steam users to entirely disregard economy of fuel, nor so expensive as to compel them to obtain the greatest economy at whatever cost; or in other words, when steam coals can be purchased at from 13s. to 20s. per ton.

In order to illustrate more distinctly our position, we will endeavour to compare the three types of engines mentioned above, and for this purpose will presume 20 horse power is required, and that coals sufficiently good for the purpose may be purchased at about 16 shillings per ton. We will also assume that the boilers are in each case of first-class workmanship and design. Upon these assumptions, the amount of coal consumed per diem by a common high-pressure engine, may be taken at 8lbs. per horse power per hour, or, omitting the amount consumed in getting up steam, which will be the same for all, 1,600lbs. per day of 10 working hours. If in the place of this engine, is fixed, one similar to that shown in Plate 373 having expansion gear attached to it, the consumption of fuel according to the several average results would be reduced to about 5lbs. per horse power per hour or 1,000lbs. per day. Again, if for this engine, be substituted an expanding and condensing engine, the consnmption of fnel will be still further reduced to about 4lbs. per horse power per hour or 800lbs. per day. The consumption of fuel is, however, not the only item whereby to calculate the economic value of an engine. It is a usual, and we believe, a very correct plan to allow 5 per cent. interest upon the capital expended npon the purchase of the engine, and 10 per cent. npon that capital for depreciation, or wear and tear. Now, the first oost of laying down the three types of engines at present under consideration, may, we think, be fairly taken as follows:—A 20-h.p. high-pressure engine at £12 per horse power, £240; a do. with expansion valve at £14 per horse power, £280; a do. expanding and con-

densing at £20 per horse power or £400. Tabulating the above we have the following :—

Description of Engine.	Cost of coals per annum.	Interest and wear and tear.	Total.
Common high pressure..................	£180	£36	£216
High pressure and expansion	£112.10	£42	£154.10
Do. do. and condensing	£90. 0	£60	£150.

From the above table, it will be seen that the economical value of the two latter classes of engine are almost identical. Although in this case the condensing engine has slightly the advantage, several considerations have for the sake of simplicity been left out of the question. Thus, it is not always that sufficient water can be obtained for the purposes of condensation, and of course where water has to be purchased, the working expenses would be largely increased. Moreover it is doubtful whether many steam users would be satisfied with investing an unnecessary amount of capital at only five per cent.

Again, the management of a condensing engine demands higher skill than that necessary for a non-condensing engine, although we would not lay much stress upon this point, as, we consider it to be very bad economy to employ any but first class men for the management of any machinery whatever.

The engine illustrated in Plate 373, and which has been designed and manufactured by Messrs. Charles Powis and Co. of Millwall, is a very good example of a high pressure engine fitted with variable expansion gear. Fig. 1 is an elevation, Fig. 2 a plan, and Fig. 3 illustrates the arrangement they have designed for varying the cut off. It will be seen from Fig. 3 that this consists of an eccentric, working a fixed link of the usual description by means of a sliding block. This block is raised or depressed by means of a screw, which can be varied to any required height by means of a hand wheel at the top. By this means, the throw of the cut off eccentric, and, consequently, the degree of expansion may be varied to the greatest nicety, while from the impossibility of any "play" in the sliding block, the wear and tear is very trifling. We remember about 10 years ago. attempting to vary the position of the sliding block in the link, by means of the governor ; it was found, however, that the angular pressure consequent upon the variable position of the link, had a tendency to raise or depress the block, which in turn imparted that tendency to the governor balls. The consequence was that, at every stroke of the engine, the governor flapped its wings to such an extent as to render a modification of the arrangement imperative. In the present instance, as we have already observed, no such contingency can possibly occur, and as far as we can judge, the arrangement is both simple and effectual.

The following are some of the particulars of the 10-H.P. engine, illustrated by Plate 373. The cylinder is $10\frac{1}{2}$in. in diameter, and 18in. stroke, steam ports 8in. by $1\frac{3}{8}$in., exhaust do. 8in. by $2\frac{3}{4}$in. The cut off valve works on the back of the main slide, and receives motion as shown in Fig. 3 from a separate eccentric actuating a fixed link. By varying the position of the block in this link, by means of the screw and hand wheel, the amount of expansion can be regulated with the greatest nicety. The cylinder has a steam jacket cast round it, which receives the steam direct from the boiler and is fitted with the usual means for drawing off the water of condensation. From the above remarks, it will be seen, that although there is not a great amount of novelty in its construction, it is an excellent specimen of a thoroughly substantial and useful engine, possessing in a large degree the elements of economy, both as regards first cost and in its consumption of fuel.

It is said that Mr. Reed, the late Chief Constructor of the British Navy, has received and accepted an official invitation to visit the dockyards and arsenals of Russia.

ON THE MANUFACTURE OF SUGAR IN THE COLONIES.

Evaporation.

(*Continued from page 75.*)

Our description of the various methods employed for evaporating the water from sugar would not be complete were we not to refer to a very ingenious arrangement patented in 1865 by Mr. Fryer, of Manchester, which, although originally designed to make a description of sugar suitable only for refiners, has lately been so far modified that a first-class "grocery" sugar may also, if desired, be manufactured by this process. In its original state it was, as we have already mentioned, not intended to make crystallised sugar, but only to evaporate the water so that the solid residuum might be treated by the refiner. Although, as our readers are aware, we entirely dissent from the opinion frequently expressed that sugar growers have nothing to do with the manufacture of first-class sugar, there are some cases when it may be more profitable, or at least more convenient, to prepare the juice for the refiners. The following account written a short time ago by Mr. Alliott, of the firm of Messrs. Manlove, Alliott and Co., of Nottingham, the well-known manufacturers of sugar machinery, will, with the accompanying illustrations, explain Mr. Fryer's system :—

"This machine has been called into existence by the belief that it is not the interest of the planter to compete with the refiner, but to produce the largest possible quantity of a material suitable for him to operate upon. The end aimed at by the Concretor is, then, to concentrate as cheaply and efficiently as possible, the juice which is supplied to it ; turning it at once into a solid substance, which is easily packed, and is not subject to loss by drainage. To accomplish this end, the clarified juice is first run over a series of shallow trays, in a stream of about half an inch deep ; these trays are divided by ribs running from one side nearly to the other, so that each tray forms a continuous narrow serpentine channel, in traversing which the juice passes six times from side to side of the tray.

"In the largest size there are ten of these trays placed end to end, and having connections so arranged that the juice can flow freely from end to end of this series, thus (the length of the series of trays being about 48ft.) the juice has to traverse nearly six times this distance before it passes away to undergo a further process of concentration in the revolving cylinder.

"Heat is applied to the bottom of these trays by means of the furnace, the flame of which passes under the whole length ; the juice is concentrated by means of this process to a density of from 30° to 34° Beaumé. After leaving the trays the juice passes into the revolving cylinder, where it is made to expose a very large surface to the action of heated air drawn through the cylinder by means of a fan. The air itself is heated by passing amongst and around a number of tubes in the air heater, through the inside of which tubes the products of combustion pass to the chimney.

"In this cylinder the concentration is continued until the material has attained such a consistency that it drops in large flakes instead of flowing in a continuous stream. When this degree of consistency is attained, it is discharged from the cylinder into casks, or any other convenient receptacle, and in cooling becomes a solid mass, which without any further manipulation is ready for shipment.

"The whole of the operations mentioned above do not occupy more than about half an hour, while the supply of juice to the machine and the discharge of concrete from it are each of them continuous, or nearly so, both objects being effected without stoppage, and without any interference with the working of the machine.

"No molasses is made, but the average yield of concrete is about two pounds to the gallon of juice, gauging $10\frac{1}{2}$° Beaumé. The material thus produced sets into a solid mass, which contains uninjured in quality or colour all the saccharine matter held in the juice from which it is made ; it is not subject to any perceptible drainage on the voyage to England and is precisely the article required by European refiners."

The yield here mentioned, viz., two pounds to the gallon of juice at $10\frac{1}{2}°$ Beaumé, appears extraordinary, in fact it is the total theoretical quantity that could be obtained; but we must bear in mind that the material is called concrete—not sngar—and of course if nothing else is done but to evaporate the liquid the total theoretical amonnt of solid must remain.

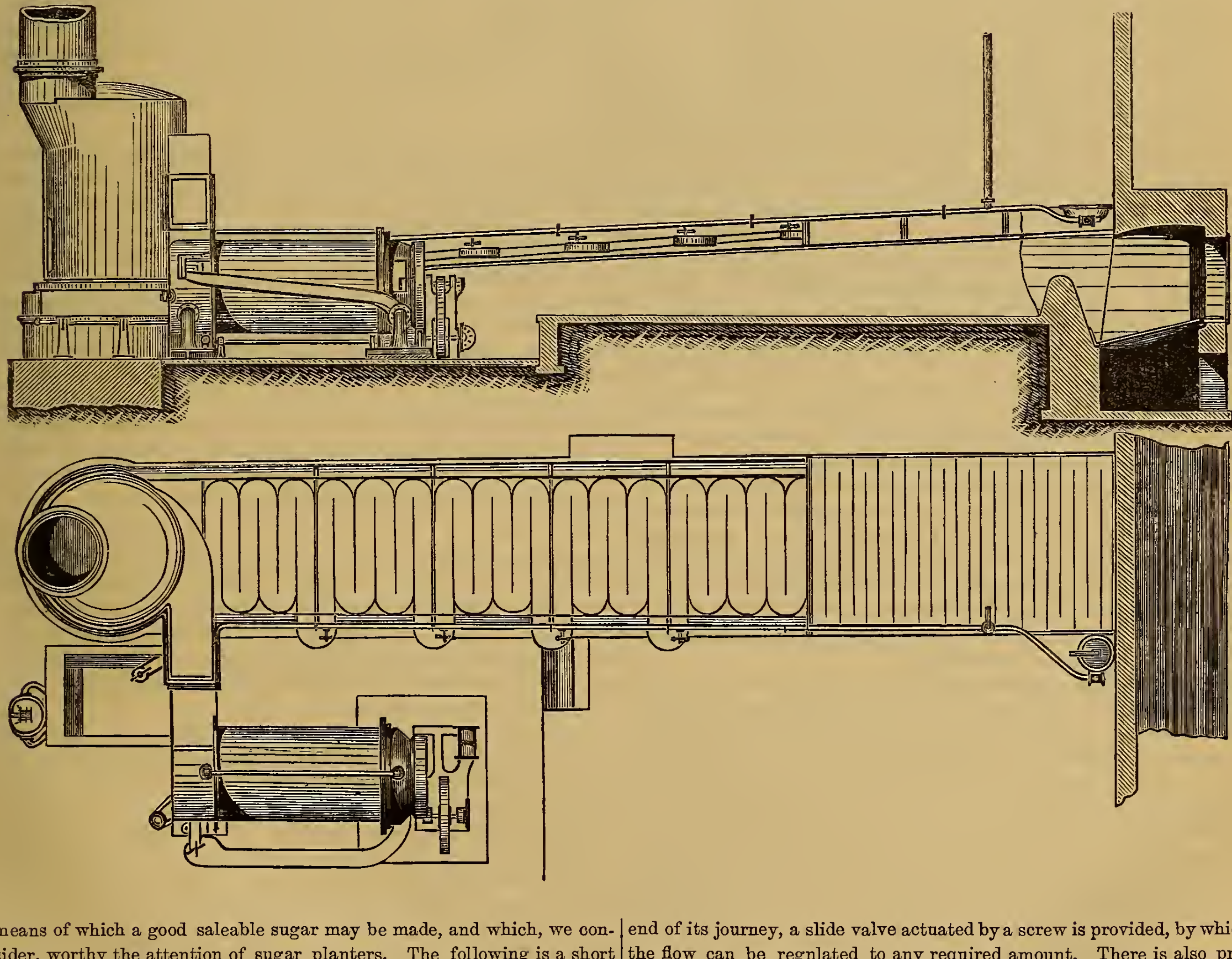
We have seen specimens of the concrete manufactured by this process, and it appears most thoronghly to answer the purpose for which is is intended, viz., to be re-manufactured by refincrs in a precisely similar manner to that at present adopted for raw sugar from the Colonies. We have already stated that in our opinion a first class grocery sngar onght to be manufactured directly from the cane, consequently, we do not consider that this process, excepting in peculiar cases, is to be recommended. There is, however, another method of working the same apparatus by whiteness of the sugar were thought to be more important than the cost of its production.

"In the revolving cylinder thc syrup is not concentrated to quite so high a point as if 'concrete' sngar were to be made. From the cylinder the syrup is passed into coolers whcre it is allowed to stand for 24 hours to crystallize; after this it is drained in the centrifugal machine."

"The molasses obtained from the 'first sugar' may be boiled down a second time in the revolving cylinder to produce 'second sugar.'"

As it is evident that in this plan of working, the juice cannot be skimmed or otherwise manipulated while in the trays, grcat care should be taken in its treatment in the clarifiers previous to its entering the concretor.

In order to regulate the flow of juice into the concretor, so that it shonld arrive at the proper degree of concentration when arriving at the



means of which a good saleable sugar may be made, and which, we consider, worthy the attention of sugar planters. The following is a short description of this plan, as given by the manufacturers:—

"The process of concentration is condncted much in the same way as in No. 1 method, except that the syrup as it leaves the concretor 'trays' ought cither to be filtered throngh bag filters, or allowed to subside for 24 hours before it passes to the cylinder. The object of this filtration is to remove any mechanical impurities left in the juice, which, if not removed, would be likely to impart an objectionable gray tinge to the sugar.

"Charcoal filters might be employed at this stage of the process, if the end of its journey, a slide valve actuated by a screw is provided, by which the flow can be regnlated to any required amount. There is also provided a pipe, fitted with a series of cocks as shown in the illnstrations, by means of which, should the juice become too highly concentrated, the weak liquor can be permitted to flow into any of the lower trays. In addition to this there is a pipe for the purpose of returning the liquor, should it after finishing its course be found not sufficiently concentrated, to be passed into the revolving cylinder. Thus, it will be seen, that by means of these two arrangements, perfect provision is made for any variation in the strength of the cane-juice, or in the temperature of the heated gases beneath the trays.

MECHANICAL TESTS.

Much time and thought have been expended by some of our most competent mechanicians in devising means and apparatus for testing the strength of materials, and at the present time we certainly possess great facilities for applying various kinds of strains to any samples we may desire to experiment upon. There is, however, a matter requiring most serious consideration which has reference to the valne of the tests after they are performed, and the interpretation of the results which proceed therefrom: for experience shows that although a sample of material may withstand a certain test once or twice, yet at some future and perhaps not very distant time that same samplo will rupture under a strain not equal to that applied at the time of testing, but considerably below it.

Under these circumstances it is evident that much judgment should be used in arranging mechanical tests, and also in drawing conclusions from them as to the quality of the material examined; wherefore we purpose devoting the present article to the subject of mechanical tests so far as they relate to iron.

Some engineers have a great objection to iron which stretches notably previous to its fracture, bnt for purposes where the structure in which the iron is used is liable to alterations of strain, producing vibration and concnssion, this description of metal is decidedly preferable. Good bar iron for girders and bridgework may stretch nearly but not more than one inch per foot previous to fracture, and ultimately break at about 23 tons to 25 tons per sectional square inch. Iron which will not stretch much is usually hard, and of less ultimate strength than the softer material here alluded to. About three-quarters of an inch as the ultimate elongation per foot may be very fairly specified for the class of work to whioh we are alluding, bnt there should be no perceptible permanent elongation (or permanent set as it is more commonly called), until the strain has reached at least ten tons per sectional square inch. In stretching the bars or pieces of plate necessarily become reduced in sectional area, and it may be worthy of notice that they contract chiefly in width, and scarcely at all in thickness, if they be tolerably thin, which is probably due to the position in which they are rolled in the iron mill; for the thickness of the bar or plate being determined by the distance of the rolls between which it is drawn, and its being sqneezed through snch rolls it follows that the various layers or lamina of metal are pressed very close together, so as to strongly resist being brought into nearer proximity, whereas there being little or no pressure laterally upon the bars, the fibres are not in this direction so closely packed; thns the bar becomes narrower more readily than thinner than it was previous to being snbmitted to the process of testing.

In testing structures or machines of any description especial care should be taken to guard against *over testing*, and no test should ever be applied much in excess of the greatest strain to which the material will be subjected in ordinary work; for if the iron be once injured the injury will be continually augmented by even moderate loads, and at last the work will give way under a strain perhaps one-half of the test load originally applied. In fact, we have no doubt that in many cases of accidents which have occurred, even after years of satisfactory working, the cause of disaster is to be found in original over-testing of the metal inaugurating a slight flaw or lesion of fibre which has gradually but surely increased, until at last the sectional area of tho material which remains is insufficient to do even its ordinary duty.

The safe working strain on iron is abont one-half of that load which produces tho first permanent set, and this, as we have stated above, should not occur under less tension than ten tons per sectional square inch, or say 20,000lbs., hence the safe working load in tension on plate and bar iron may be taken at 10,000lbs. per square inch of sectional area. In compression the permanent set should commence at abont 16,000lbs. per inch, therefore the safe working load wonld be taken at 8,000lbs. per square inch of sectional area.

Now, let us see what is the proper course to pursue in testing material of which it is proposed to construct bridges or other works in iron. First, as to the terms of the specification, let us assume that the iron is not to stretch more than three-quarters of an inch per foot before rupture, and not to break under 44,000lbs. per sectional square inch. In the first place, portions taken from plates, flat bars, and angle and tee irons for the purpose, should be tested, in order to ascertain their qualities; this done, the iron used in the work should be examined carefully to see that there are no visible flaws in it, and if there be large masses of metal the fire test or the magnetic test may be applied to ascertain if there are within it any imperfect welds, or "cold shuts" as they are technically termed; and when the work is complete it should be finally tested by loading it with the greatest load that can ever come upon it. This load should be left upon it long enough to allow the rivets, bolts, &c., to take their bearings (say twenty-four hours), after which it should be removed, the permanent set due to imperfect joints noted, and the load applied again, on removing which there should be no further permanent set notable. It may, however, in some cases happen that the joints will not all come down at the first loading; but there is a point in every structure at which it will cease increasing its permanent set with recurring loads, if it be sufficiently strong to do its ordinary duty satisfactorily.

Thus, to take an example to show how over-testing may lead to subsequent accident, although at the time no injury is visible from the test applied; let it be determined to test some iron to 15,000lbs. per sectional square inch, and suppose there is a flaw in the metal which loses one-fourth of its area, then the actual strain per square inch on the remaining section will be 20,000lbs.; hence on that part the point of permanent elongation is reached, and in the course of time successive loads continue to stretch the metal until at length it gives way altogether. Now, if that metal had only been tested to a little over 10,000lbs., the load which it was intended to sustain ordinarily, the metal would not have been injured even at the defective place, bnt would probably have done its work satisfactorily. On the other hand, it may be said that perhaps the load of 10,000lbs. might start an injury on some part of the structure—and even that might be the case—but still it is useless to run unnecessary risks of depreciating the strength of the material.

While speaking of the inutility of severe tests we may refer to an accident which occurred some time since to a large chain of the description known as short-linked. The chain in question was tested to a load of over sixteen tons gross weight, and a few weeks after snapped under a load which did not exceed eight tons. The fractured link exhibited a cold shut, showing that half the area of metal in the link was lost. A portion of the same chain tested to fracture showed an ultimate strength of over twenty-five tons gross load.

In our opinion in respect to the question of chains a portion of any given chain should be cut off and tested to its breaking strain, and the remainder, or that part which is intended to be practically applied, should be tested to a load but slightly exceeding that to which it will be habitually exposed; and subsequently it should be submitted to the fire test, which is condncted as follows:—Tho chain is gradually passed through a smith's fire, and every link carefully examined when at a clear red heat, water being poured on each link, when any defective shut is sure to show itself, and all defectivo links must be then cut off and replaced by sound ones. With chains thus examined we have never had an accident in use, but have sometimes found two or three bad links in one length which had passed tho ordeal of a licensed testing-house, thus showing that the ordinary chain-test (unfortunately too much relied upon) is, in a practical senso, no guarantee at all of tho safety of the chains tested, which, by tho way, might be further instanced had we spaco to multiply examples.

The remarks made above on tho over-testing of iron girders will of course equally apply to wrought-iron boilers, and, indeed, it seems absnrd to test a boiler up to a pressure of eighty or ninety pounds per

square inch which in actual working will never contain more than thirty pounds per inch, and this is another instance of trying to be too sure.

We will now pass on to the question of testing cast-iron girders. Here it may very easily be shown how important it is that the metal should be sufficiently elastic to allow of a notable amount of deflection before fracture, and more especially if the case of a sudden concussion be taken for example. If a body falls a certain distance it acquires a corresponding amount of *accumulated work* supposing there has been no resistance to its motion while falling, and this work is represented by its weight multiplied into the distance through which it has fallen. Let the weight equal 10,000lbs., and suppose that the height of its fall is forty inches, then the amount of accumulated work acquired by the mass during its fall will be—

$$10{,}000\text{lbs.} \times 40\text{in.} = 400{,}000 \text{ inch-pounds,}$$

that is to say, work equal to 400,000lbs. raised one inch high.

Let us now assume that there are two cast-iron girders of equal ultimate strength, that is to say, that they will both break with the same weight *laid* upon them *gradually*, but that one deflects two inches and the other three inches previous to rupture, that is to say, the latter deflects under a given load fifty per cent. more than the former, we shall find the one that deflects most suffers least from the blow of the falling weight. The amount of accumulated work in a body being known, and the distance through which it has to pass in *expending* such work, the force or pressure is ascertained by dividing the accumulated work by such distance. Now, the distance through which the weight has to pass is represented by the deflection of the girder, consequently in the two cases we have the following means, loads, or pressures on the girders:—

$$\text{First girder—Mean load due to concussion} = \frac{400{,}000}{2} = 200{,}000\text{lbs.}$$

$$\text{Second girder—Mean load due to concussion} = \frac{400{,}000}{3} = 133{,}333\text{lbs.}$$

Hence the girder which deflects most suffers least mean load from the fall of a weight upon it, and what is true of a concussion thus produced must be true of all concussions.

Having thus set forth the practical conclusions to be drawn from mechanical tests we shall close the present article, but probably shall before long resume the subject.

TRIAL TRIP OF H.M.S. "SULTAN."

In The Artizan of February, 1869 (p. 26), an analysis of the performance of H.M.S. *Hercules* was given, which illustrated, as our readers may be aware, the high perfection of the motive power, but at the same time demonstrated that whatever might be the excellence to which they attained, short ships with full lines could never be advantageously propelled by steam, at least for ocean-going purposes. In order to construct an impregnable vessel carrying its deck a sufficient height out of the water to carry masts, or one as nearly as possible impregnable, Mr. Reed has been compelled to adopt full lines, and has rather ingeniously thrown the onus of obtaining the speed upon the engineers. In the present instance Messrs. Penn and Son have undoubtedly proved themselves equal to the occasion, although the tax even upon their resources must have been very severe. An indicated horse-power of 9899·81 is a feat that we believe has never been before accomplished; but when we think of the amount of coal demanded for that purpose we are tempted to ask how many hours such a power could be continued. In our remarks respecting the trial of the *Hercules* we mentioned, and we believe correctly, that that vessel could not carry two days consumption at full power, and when we consider that the displacement of the *Sultan* was at the time of trial only about 140 tons in excess of the *Hercules*, while the power exerted was 1,370 H.P. in excess, we cannot be far wrong in assuming that two days consumption of fuel at full speed is more than she is calculated to carry. Whether a vessel with a coal-carrying capacity of less than forty-eight hours may correctly be termed a sea-going ship we leave our readers to determine; for ourselves we cannot but protest against the futility of the attempt to build high-sided, heavy-plated vessels under the mistaken impression that as one type of vessel has in former years served our purpose, it must *a fortiori* be equally effective in the present progressive state of naval architecture. We think most naval architects and engineers will agree with us when we assert that no sea-going ship can be made impregnable unless it has to depend upon steam alone, when the sides may be reduced to a moderate height; and also that vessels like the *Sultan* and *Hercules*, although probably more formidable than those possessed by any other nation, are ill adapted for such purposes; while from their excessive draught they are, in many localities, equally useless for coast defences. As, however, we intend shortly to recur to this subject, we will now confine ourselves to giving the actual results of the trials, together with a few particulars of the vessel:—

The engines of the ship are of 1,200-horse power nominal. They are precisely similar in arrangement and dimensions to those of the *Hercules*, also from the factory of Penn and Son. The cylinders have an internal diameter of 129in., the trunks 41in., and the pistons a stroke of 4ft. 6in. The furnaces give 19½ft. of heating surface per nominal horse-power of the engines.

On the 3rd ult. the *Sultan*, manned by officers and men from the flagship and the reserve, and commanded by Captain E. Rice, of Her Majesty's ship *Asia*, A.D.C. to the Queen, left Portsmouth harbour, and steamed off some distance into the Channel S.E. of the *Nab* lightship, for a preliminary trial of her machinery. The maximum rate of speed of the engines during the run off was 69½ revolutions, and this gave an indicated power of 8,374·91 horse. On nearing the land again, in returning towards Spithead, the anchors were dropped abreast of the *Nab*, and the steam capstan with its engine tested in heaving up the anchor again, and found to answer perfectly. As an auxiliary to the ship's ordinary rudder, and in the event of any damage being received by the latter, the ship is fitted on each quarter with a "fin" board, which, when lowered, projects out from a recess in the ship's hull at an angle of about 60 degrees. The action of these was tested after leaving the vicinity of the *Nab* again, on completing the trials of the steam capstan and its engine, and they were found to have no effect whatever.

On the 6th ult. the ship's anchor was weighed from Spithead, for her speed trials over the measured mile in Stokes Bay. The ship's draught of water was 23ft. forward and 26ft. 10in. aft—a mean draught of 24ft. 11in. The weights on board were nearly 400 tons short of what the ship will have to start to sea with, but as she had 350 tons of ballast in the compartments of her double bottom she steamed over the mile at, as nearly as possible, her designed load line. The estimated weight of the ship's hull is 3,961 tons, and the weights actually carried may be taken as 4,856 tons. This gives a total weight of 8,827 tons for the engines to drive through the water. The estimated displacement of the ship at her load line was 8,900 tons. The weight of armour-plating used in her construction was 1,500 tons; and, the weight of one broadside of shot fired from her 18 and 12 ton Frazer guns would be 1,965lb.

Commander R. H. Swinton, of Her Majesty's ship *Asia*, was in command of the ship for her trial, and the other officials on board comprised Mr. Barnaby, President of the Admiralty Council of Construction; Mr. James Steil, Admiralty Inspector of Machinery; Mr. Oliver, Chief Inspector of Machinery at Portsmouth; Mr. W. Eames, Chief Inspector of Machinery at Chatham; Assitant Master Shipwrights Broad and Newman, of Portsmouth-yard, and other officers. Messrs. Penn and Son were represented in the engine room by Mr. Anderson. Admiral Ryden and Captain Field, R.N., were also on board.

The frigate, after getting her anchor at Spithead, was taken out by the *Nab* Channel to clear her fires and work up her engines preparatory to her six consecutive runs over the mile. Her engines soon rose to 70 revolutions per minute, and her course was then reversed for Stokes Bay, where she commenced her trial. Through the first three runs all appeared to go very satisfactorily, but in the middle of the fourth run it was found necessary to stop the trial owing to the heating of the after crank bearings.

The runs made over the mile were quite sufficient however to prove the speed of the ship under a maximum pressure of steam, and also the power that could be indicated by the engines. Timed by one of Benson's chronographs the ship was 4 min. 17 sec. in running over the first mile against the wind, at a force of 5, and against tide, and 4 min. in running over the second mile with the wind and tide. This gives the ship a speed of 14·008 knots for the first mile and 15 knots for the second, the mean speed of the ship, therefore, being 14·5 knots. The revolutions of the engines at the commencement of the first mile were 72·25, and reached 72.75 on the third mile. The mean steam pressure was 22lb., and the actual horse power indicated by the engines as calculated from the diagrams on the indicator cards reached the enormous figure of 9,899·81—over eight times the nominal power, and a result altogether unprecedented.

COMPOUND ENGINES.

By Charles E. Emery, M.E. (U.S.)

With reference to my views concerning the advantages of the componnd over the single engine, and the causes of the advantages, particularly for propellers, I consider that the compound engine may be applied with superior results in any location where economy of fuel is desired. I give two points ot superiority, with explanations and discussions as brief as the subject will admit.

Advantages of the Compound Steam Engine as compared with the ordinary Double Acting-engine.

1. It furnishes a better working engine mechanically, for utilising the benefits of the expansion of high-pressure steam. This point will be very generally conceded. The expansion of steam is necessary to secure economy; but, if the application of the principle be carried to the extent desired, the great changes of pressure in the cylinder cause severe strains on the main connexions, and, although the latter be made unusually strong, it is frequently found expedient to reduce the pressure, and, necessarily, the measure of expansion, and so increase the consumption of fuel in order to reduce the losses cansed by frequent repairs, but more particnlarly by the delays they occasion. The compound engine, in any form, equalises the strain and distributes the load.

2. Independently of mechanical considerations, it is more economical to use steam expansively in a compound engine than in any form of the ordinary engine. This point mnst be accepted as a fact by any one who will examine the evidence available, but the abstract explanation of the result is impossible by any of the laws heretofore laid down in respect to the steam engine.

It should be borne in mind that, contrary to the opinion of many, there is no gain in power by the addition of the small high-pressure cylinder of the compound engine, for the effective pressnre upon its piston is only the difference between that of the entering steam and that admitted to the second cylinder. There is, in fact, a little power *lost* in transferring the steam from one cylinder to the other. It is not strange, then, that nearly all American engineers condemn the compound engine, and declare, in spite of all failures, that the same result can be produced in a single engine if it be made of snfficient strength to withstand the unequal strains. These engineers simply jndge from the information they have had the opportunity of acquiring. They have been taught that the capacity of the cylinder is the measure of the steam used, and reason that, if the compound engine gives no more power with the same steam, it is a useless contrivance. No other conclnsion could be based on snch an assumption. The error in the reasoning lies in the fact that the volume of the cylinder is not an accurate measure of the qnantity of steam used by the engine. This fact has been proved by experiment both at home and abroad, but, strange to say, has never attracted mnch attention. People will assume that steam can be measured by the cylinderful as accurately as peas in a bushel; but the fact is, that the metal walls of a steam cylinder are at every stroke so cooled by the performance of work, and by the low temperature during the exhaust, that the live steam, npon entering, has two offices to perform, namely, first, to reheat the surfaces; and, second, to fill the cylinder and maintain the desired pressnre. In many cases, it may require as much steam to do the first as the last; and, as the steam for the first pnrpose is condensed, that for the second will only fill the space, and, in fact, two volumes of steam may enter into a vessel capable of holding but one of a liquid or non-condensable gas. During the Government expansion experiments and others of a private charater, I had ample opportunity to ascertain the accuracy of the above views, and found that the benefits to be derived from expansion were, in the manner stated, greatly redneed, though not entirely overcome, as had in some cases been claimed. I believed these losses conld be prevented, and, with means furnished by capitalists, tried over two hundred and fifty experiments to ascertain the value of various devices for accomplishing this end. The nature of the loss was proved in the following manner; I constructed two cylinders of like dimensions, one of glass the other of iron, in such a manner that either conld be attached to a valve which regularly admitted steam from a boiler to the cylinder, and permitted its exhaust into a condensing coil lying in a tub of water. The capacity of the two cylinders was made exactly the same, as was shown by transferring water from one to the other. Wheu put in turn in the condition of a steam engine cylinder, the iron cylinder used (averaging the experiments) fnlly twice as much steam as the glass one, shown by the fact that twice the quantity of water came through the condensing coil for the same number of movements of the valve. Steam of the same pressure was used in both cylinders, aud the experiments were many times repeated with substantially the same results. This settled the question: the glass cylinder saved half the steam. The cylinder of a perfect engine should, then, be made of glass or other non-conducting material, which may be explained in the following manner: Tyndall has found that aqueous vapour is one of the most powerful radiators and absorbents of radiant heat known. Steam, when slightly chilled by the performance of work, is in respect to heat in the same condition as the aqueous vapour of the atmosphere; therefore, if steam enter a cylinder at a temperature of, say, 280°, and heats the metal surfaces to that point, when snch steam is exhausted and falls in pressure so that the temperature is, say, only 130°, the snrfaces rapidly radiate heat, which is absorbed by the steam and carried to waste, and the next steam that enters has to reheat the surface, and an additional qnantity is required to fill the cylinder and do the work. A non-condncting cylinder does not become cooled; it is not necessary, therefore, to reheat it, and only the exact quantity enters which is required to fill it. I experimented considerably to make an engine with a cylinder of non-conducting material, and only desisted temporarily when it occurred to me, and I proved by experiment, that very nearly the same resnlt could be obtained by the nse of a modification of the compound engine, which involved no difficult mechanical details. The transfer of heat from the metal walls of the cylinder to the exhausting steam takes place in two ways, namely, by direct contact and by radiation. The bulk of the steam can only be acted upon by radiation, which, therefore, causes the material part of the loss. It has been proved by experiment that the quantity of heat transferred from a radiating to an absorbing body varies as the square of the difference in temperature; so, taking the previous case, namely, that the temperature of the metal surfaces of a steam cylinder is 280°, and that of the exhanst steam 130°, the difference in temperatnre is 150°; and, if we use the steam in two cylinders instead of one, we may reduce the temperature in each to, say, one-half that amount, and the condensation will be as 1^2 to 2^2, or one-fourth as much in the two cylinders as in the single one, or not less than one-third as much if an allowance be made for the increased surface in the two. This explanation shows that, if the condensation in the single cylinder be one-half the whole amount, two-thirds of this or ($\frac{2}{3} \times \frac{1}{2} =$) *one-third of the whole* may be saved by a compound engine—which calculation agrees with the facts, but varies, of course, with changes in the conditions. The explanation once obtained, it enables one who has stndied the subject to proportion the componnd engine so as to obtain maximum efficiency. I have known many of them that were so constructed that they gave but little better results than a single engine. In addition to the above, it is well to state that during the experiments several improvements applicable to the compound engine were worked out, and which, in connection with that principle, using a steam pressure of only 40lb., reduced the cost of the power iu the experimental engine from 39·2lb. of feed water per horse power per hour to 23·6lb. This proportion of saving would, in a larger engine, reduce the cost to as nearly that promised by theory as the most sanguine could expect; for larger engines are positively known to be more economical than small ones, which may be explained by the fact that the ratio of internal surface to capacity decreases with the size of the cylinder.

Further details wonld make this paper too lengthy, but at some future time I shall be happy to furnish a more elaborate statement of my views on the subject, if desired. The practical evidences of the advantages of the compound engine are overpowering, as nearly all the large ocean steamships recently constructed abroad have such engines. One of these vessels, 400ft. long, according to the statement of a representative, crosses the Atlantic inside of twelve days, with a consnmption of only 40 tons of coal per day.

SOCIETY OF ARTS.

THE PATENT LAWS AND THEIR ADMINISTRATION: WITH SUGGESTIONS FOR THEIR AMENDMENT.

By Mr. A. V. Newton.

(*Concluded from page* 90.)

Section VI.

Compulsory licenses have been suggested as an antidote to what have been termed obstructive patents, and with the object of removing a real grievance urged by opponents of patent-right. This proposal has, as might have been expected, met with much opposition, but pnblic opinion is strongly inclining in the direction of controlling the power of patentees to their own advantage. It is not wise to assume, as the law now does, that patentees must necessarily know their own interests and act accordingly; for examples may be cited, although happily but few, where they have not only stood in their own light, but greatly hampered trade transactions by a stolid refusal to grant a right to work under their patents. One such example would be enough to show the need for a change in the law; but the establishment, by statute, of the right of the public to work under every patent on the payment of proper

remuneration, would unfetter inventors who, following the lead of an original inventor and patentee, might, through superior advantages, enhance to the public the value of the ideas embodied in the original patent, instead of being driven to shifts, as is often the case, to avoid the ground covered by that patent, or working in uncertainty as to the possibility of bringing into use, during the patent's existence, important improvements thereon.

The difficulty of assessing the value of a license I hold to be rather imaginary than real. On a former occasion, when discussing this question,* I suggested two modes of fixing the rate of royalty to be paid by the licensee. The first was that for an improvement upon an existing manufacture the royalty should not exceed one-third of the pecuniary benefit derivable from the application of the invention. Thus, for example, if by introducing an improvement into a machine the cost of manufacture is reduced, say three pounds, without enhancing the value of the machine when constructed, the royalty payable to the patentee should be one pound. Or if the cost of the machine to manufacture remained the same, but the efficiency was increased to an extent that would command an increased profit on its sale of three or thirty pounds, then the maximum royalty would be either one or ten pounds.

The second plan was that "where a new manufacture is the subject of a patent, and no criterion for forming an estimate such as those above indicated exists, the basis for a settlement of the terms of royalty might be that the licensee shall be able to compete with the patentee in the market, while selling at the latter's fixed price of sale." In such a case the royalty must vary with the rate at which the patentee fixes or maintains the marketable price of his manufacture, the royalty being adjusted so as to ensure to the licensee a fair manufacturing profit, when selling at the patentee's prices.

A controlling power should, I think, be vested in some officer connected with the Patent-office, whose duty it should be (in the event of a patentee and a proposed licensee not coming to terms) to determine, 1st, whether a case has been made out for acquiring a license; 2ndly, whether the time has arrived for granting a license; and, 3rdly, what shall be the royalty within the limits already prescribed. Were such a system adopted as that above indicated, I think no difficulty could arise in the working out of compulsory licenses.

Section VII.

The last subject with which I shall trouble the society relates to the payment of the periodical stamp duties on patents. It is well known that, by the Act of 1852, patentees are required, in order to keep their patents alive during the term of fourteen years for which they are granted, to pay, at the end of the third year, fifty pounds, and at the end of the seventh year one hundred pounds. These payments are made at the Stamp-office, and a stamp is required to be put on the patent itself, after which the fact of payment has to be recorded in the Patent-office, and a certificate endorsed on the patent itself.

Provision is made that if a patent be lost or destroyed, a duplicate may be obtained on which to place the stamps and the certificates of payment; but there is no provision against the sacrifice of a patent by the non-payment of the duties within the third and seventh year respectively, through oversight or accident, to say nothing of temporary want of means or other cause beyond the control of the patentee. The consequence is, that numbers of valuable patents fall to the ground, and go to swell the number of those which, failing to be renewed from other causes, are constantly referred to as a proof of the mass of useless schemes that are brought under the cognizance of the Patent Law.

A simple remedy would be to allow, as in Belgium, a period of grace within which a patentee, on the payment of a fine, should be allowed to have his patent stamped and certified, and no valid objection could be raised against this arrangement. The only course now open to a patentee is that costly and uncertain one of applying to Parliament for a private act to revive his expired patent. Several applications of this kind have been made, and three only, as I understand, have been successful. It would surprise many persons to be informed how frequently patents are lost from unintentional neglect to comply with the provisions contained in the grants themselves.

In conclusion let me briefly recapitulate the deductions drawn from the foregoing arguments.

Recapitulation.

1. The objections raised by leading opponents of the principle and action of the patent laws having been examined prove to be groundless or untenable.
2. By subjecting all allegations of infringement of a patent, and all answers made to such allegations to an examining officer for the investigation of their merits, with the view of determining whether any, and, if so, what questions should be submitted to the judgment of a court of law, litigation would be diminished, and the value of patent property would consequently be enhanced.
3. The preliminary examination of applications for patents generally demanded would be costly, and the means for effecting it have yet to be created.
4. The principle of an official examination, if adopted, should be limited to the provisional specifications, and the responsibility of providing a satisfactory complete specification should rest, as at present, with the patentee.
5. The law officers and the Judicial Committee of the Privy Council should be relieved of their respective duties of granting certificates of disclaimers, and of advising the Crown with regard to the extension of patents.
6. A system of compulsory licenses should be adopted in the interest both of patentees and the public.
7. For the payment of the periodical stamp duties on patents, if these are retained, grace should be allowed, a fine in lieu of the sacrifice of the patent being imposed, to ensure prompt payment.

* See pamphlet entitled "The Operation of the Patent Laws, with Suggestions for their better Administration." Trubner and Co., 1864.

ROYAL GEOGRAPHICAL SOCIETY.

The ninth meeting of the present session was held on Monday evening, the 27th of March, Major-General Sir Henry C. Rawlinson, K.C.B., Vice-President in the chair. The following new fellows were elected:—Commr. John Charles Best; Joseph Cubitt, Esq., C.E.; Francis Horne, Esq.; Murdock G. Maclaine, Esq.; H. M. Macpherson, Esq.; Lieut. William W. Vine, R.N.

A letter was read from Sir Samuel Baker, addressed to Sir Roderick Murchison, from Toofikeeya, on the White Nile, in Lat. 9° 26′ N., and dated the 6th of December last. Sir Samuel was then breaking up his quarters near the mouth of the Giraffe River, and had despatched the main body of the expedition to Gondokoro, himself preparing to follow with the rear. Whilst waiting for the favourable season since July last, he had made a journey to Khartum (680 miles by river), to assure himself that the requisite preparations were made, according to his previous instructions to the governor. His fresh troops and supplies followed, from Khartum. on the setting in of the north wind, and he was able to despatch his first division in eight vessels on the 1st December to Gondokoro. During his stay at Toofikeeya he had entirely suppressed the slave-trade of the White Nile, and he trusted that England would appreciate the sincerity of purpose of the Khedive (who had supported him unflinchingly in this unpopular proceeding) in thus purifying the river from the abominable traffic. The expedition would cut its way through the accumulation of marsh-plants by way of the Bahr Giraffe. On arriving at Gondokoro it was his intention to proceed by land to Ibrahimeya (3° 32′ N. lat.), bringing two life-boats and the 80ft. steamer in sections by carts; having thus passed the cataracts which obstruct the river above Gondokoro, he would explore the smooth waters of that part of the river lying between the obstruction and Lake Albert Nyanza, and, if he found the course clear, would return to Ibrahimeya, put together the steamer, and embark for the Great Lakes. With the exception of Dr. Gedge, the naturalist, who had sickened and died, the party were in good health, and much was due to the exertions of Lieut. J. A. Baker, R.N.

The paper read was "On the Chinese Province of Yunan and its Borders," by Mr. T. T. Cooper. The author had traversed the western portion of this remote province in 1869, after his unsuccessful attempt to cross from the Upper Yang-tsze to Assam. The mountainous country along the border was peopled by a number of separate barbarous tribes, more or less under the influence of the Chinese. The border-country is wild, but the interior of Yunan is fertile and picturesque, and exceedingly rich in agriculture and mines. All attempts hitherto made to open up a route between this fine province and our possessions in Burmah or Assam had been in vain.

After the reading of the paper, the chairman read a most graphic, and evidently truthful, description of Western Yunan by Bishop Cheanveau, who had been for fifteen years resident, as Roman Catholic Missionary, in this little known region. The chief city, Tali-fu, was situated on the shores of a beautiful lake, 45 miles long, by 12 to 15 wide. The plain on its western side formerly contained a population of upwards of 400,000 souls. The climate was fine and healthy; copious harvests, excellent fish, fruits, and vegetables; good and numerous horses and mules: a kind and gay population; such were some of its recommendations. There were nine other great plains similar to that of Tali. The city was the centre of a great trade with all the surrounding populations, and was the point whence started the caravan trade with Burmah, which formerly passed by Momien to Bhamo, on the navigable part of the Irawady. According to the Bishop, the country had much deteriorated

since it had revolted, under the instigation of the Chinese Mahomedans of Yunan, against the Imperial authority.

In the discussion which followed, Major Sladen (the Commander of the late expedition from Burmah to Yunan) confirmed the Bishop's statement—that the natural route for trade was *viâ* Bhamo, and spoke favourably of the Mahomedan chiefs, who had received him in the most friendly manner at Momien. Mr. A. Michie, of Shanghai, Dr. Barton (of the first Upper Yang-tsze Expedition), and Mr. W. Lockhart (formerly resident in Pekin), also spoke. All the speakers agreed in stating that English travellers met with good treatment, and even welcome, from the Chinese people, and that all opposition arose solely from the interested and corrupt mandarin class.

INSTITUTION OF CIVIL ENGINEERS.

THE NEW ROSS BRIDGE.

By Mr. Henry N. Maynard, M. Inst. C.E.

The author stated that this Bridge was built over the River Barrow, in Ireland, on the site of an old wooden structure, which was swept away by ice, and where the river was navigable for vessels of 2,000 tons burthen and was 650ft. wide and 38ft. deep at high water of spring tides, there being a tidal range of 25ft. The bed of the river was chiefly sandy clay, or marl, with thin layers of *debris*, the marl varying in hardness, and overlaying a bed of about 7ft. of gravel under which was rock. The timber bridge was composed of mere trestles, resting on the mud, at intervals of 25ft., and covered with joists and planking, having a portcullis of 30ft. opening, and it was said to have cost about 10s. per square foot of surface. The new bridge was of iron, and had been designed by Mr. James B. Farrell, M. Inst. C.E., Wexford, and Mr. P. Burchall, Kilkenny. It consisted of four spans of fixed lattice girders, each 88ft. in the clear, and of a swing bridge having two openings of 50ft. each. The roadway was 32ft. wide, comprising two footways each of 5ft. 6in., and a carriage way of 21ft. The road was carried between the lattice girders on cross girders and buckled plates, these plates being covered with 6in. of Portland cement concrete, then a layer of asphalte 2in. thick, upon which was laid metalling 4in. thick, except over the swing spans, where a wooden floor, cambered like a ship's deck, was laid. The piers were pairs of cast iron cylinders sunk to the rock, 9ft. in diameter at the base and 7ft. in diameter at the top, having one taper length below low water to connect them, and filled with Portland cement concrete. The central pier, under the swing span, was formed of a cluster of five cylinders braced together, upon which a strong circular girder formed a roller path for the bridge to turn upon, the turning being performed by chain and wheel gear. The abutments of the bridge were to have been built of masonry; but at the author's suggestion iron was substituted, thereby saving much time and money. These abutments were composed of three cylinders, each 7ft. in diameter, and of cast iron plates filling the spaces between them and forming also the wings. An ornamental stone parapet was built on the top of the wing plates, at the back of which, as well as inside the cylinders, concrete was deposited. Considerable difficulty was encountered at first in sinking the cylinders. It was hoped that sufficient clay would be found to hold back the water. After building up a cylinder 45ft. high, it was lowered to the bed of the river and found to reach sufficiently above the water level for the attachment of another length. The interior was then excavated by the Sand Pump, until the cylinder had sunk 14ft., when an additional length was added, and weighted as before. After remaining a few hours this suddenly sank 13ft., carrying away some of the braces of the staging which were not arranged for so great a movement. When the damage to the stage was made good, the water was pumped out of the cylinder, but the inside could not be kept dry, for as soon as the earth at the bottom was disturbed, the men were driven out by water coming up through it. Compressed air apparatus was then used, and the earth excavated to the lower edge of the cylinder. On the pressure of the air being removed the cylinder immediately went down another 13ft., and on examination there was found to be a depth of 20ft. of earth inside. This earth was taken out until good hard gravel was met with, into which the cylinder had penetrated 5ft., and as this gravel immediately overlaid the rock, it was deemed a sufficiently good foundation. Various means were tried to pump out the earth from the inside of the cylinders, but it was too tenacious to be removed satisfactorily in that way. Mr. Milroy's excavating apparatus was also used, and acted very well, but it was eventually found necessary to complete the work by compressed air apparatus. All the cylinders in the bed of the river were subject to descend suddenly, from 6ft. to 13ft., when they reached a certain stratum, and after the first was sunk suitable arrangements were made in the staging to meet this. The time occupied in sinking a pair of cylinders to the proper depth was about ten weeks. On one pair operations were commenced on the 3rd December, and the excavation was completed on the 5th February, by means of the Sand-Pump and Mr. Milroy's machine. The compressed air apparatus was then fitted on, and the cost of the whole was about £250 for labour, exclusive of the use of staging and tools. Owing to the difficulty in fixing the piers in this river, the author was led to design an open braced pier for similar cases, and stated that if it had been adopted here, a saving would have been effected of £8,000, and the work would have been executed in less time. This pier would consist of a cluster of four braced tubes of cast iron, connected together as one, with solid wrought iron screw piles passing through them; the whole braced structure, with its screws, being lowered through the water and the screws driven down inside the tubes, sliding through the latter in a telescopic manner, until they reached the hard bottom of gravel, the bracing forming a guide and stage for the screwing down, and afterwards becoming a permanent portion of the structure. The ironwork in the Piers and abutments weighed 1,182 tons, and in the superstructure 650 tons. There were besides of other materials, masonry 10,656 cubic feet, concrete 2,000 yards, timber 3,000 cubic feet, and timber in dolphins 9,750 cubic feet. The work was executed by the Messrs. Kennard Brothers, of Crumlin, under the author's superintendence, and was commenced in April, 1868, the roadway being opened for traffic in July, 1869. The total cost was £36,250 or about £2 5s. per square foot of surface. The cost of fixing, including the staging, was £7 9s. per ton of iron.

ON THE TESTING OF RAILS, WITH A DESCRIPTION OF A MACHINE FOR THE PURPOSE.

By Mr. James Price, M. Inst. C.E.

The author remarked on the importance of determining before hand the fitness of rails for their work, so as to avoid the necessity for constant replacements, which were attended with danger, inconvenience to the traffic, and unnecessary expenditure. There were certain causes of increased wear in rails which could be avoided; first, the difference in the forms of rail tops on lines worked as one system, the tires which ran on one portion not fitting the form of rail top on other parts; and, secondly, the super-elevation of the outer rail on curves not being properly attended to. To facilitate calculation in the latter case, the author had invented a rule which left out the term radius, a chord being found, the versed sine of which was the correct super-elevation for any curve. This chord, for a speed of 40 miles per hour, was 64ft. for the English gauge, and 67ft. for the Irish gauge, a chain length (66ft.) being sufficiently near for either. For any speed and any gauge the rule was—

Length of chord whose versed sine equalled super-elevation

$$= \tfrac{1}{2} \text{ velocity in feet per second} \times \sqrt{\text{gauge}}.$$

The qualities sought in a rail were fourfold:—1° Strength, as a girder, to sustain a moving load; 2° Toughness, to resist sudden strain or impact; 3° Solidity, to resist separation under pressure; and 4° Hardness, to resist wear of the surface.

Strength depended on the form of the rail and on the quality of the iron. The flange or Vignoles rail stood first, as to form, for strength, and the double-headed came next; while the bridge-rail was a bad girder-form, and 30 per cent. of such rails broke before they were worn out. The proper interval for the sleepers was determined by the stiffness of the rail used. It was argued that the deflection of the rail, under its heaviest load, when in the centre between two sleepers, should equal the difference of the depression of each sleeper when the load was in that position, and borne equally by two sleepers, and when it was directly over one sleeper. The author, having measured these deflections and depressions, found some rails too stiff for sleepers 3ft. apart from centre to centre, and some too flexible; and he adopted intervals of 3ft. 6in. for a deep-flange rail weighing 76lbs. to the yard. Rails should be tested for strength at a double interval, namely, such as would occur were every alternate sleeper left out.

Toughness might be measured by the amount of extension obtained in tearing asunder strips cut from the rail. The author had obtained from 8 to 9 per cent. of extension when the samples broke with a strain of 21 tons per square inch. Toughness, together with a hard head, could be obtained in a flange rail, but it was doubtful whether both qualities could co-exist in a double-headed rail. By solidity was meant freedom from particles of foreign matter and perfect welding. Hardness was of most consequence on inclines and at stations.

Existing modes of testing rails might be divided into: (1) Dead weight test, which was valueless as not being analogous to actual work; (2) Falling weight test, which was unfair, serviceable rails being rejected by it, as it went as far beyond the requirements of practice as the other fell short of it. Thus a rail might be bent, over a decayed or badly packed sleeper, by a train moving at the rate of 40 miles per hour, a

velocity only $\frac{1}{20}$th part as great as that with which it was struck by a weight falling only 4ft.; (3) The examination of fracture to ascertain structure was a matter of too great nicety for general use.

The machine employed by the author for testing rails subjected them to wear analogous to actual use. It consisted of a pair of metal rollers, 5ft. in diameter, 16in. wide, and weighing $2\frac{1}{4}$ tons each, supporting a circular frame or beam weighing $6\frac{1}{2}$ tons, this frame being connected by radii with a centre boss, through which passed a vertical axle. The circle traversed was 40ft. in diameter. One roller bore with 6 tons and the other with 5 tons pressure. Motion was communicated either by shafting and gearing underneath, or by the direct action of a steam-engine. The speed at which the machine could be worked was about 20 miles per hour, but it was generally run at a speed of 13 or 14 miles per hour. The rollers were caused to revolve over a ring or polygon of the rails to be tested until the rails were broken or worn out, and they bore with a weight equal to that of the driving wheel of a locomotive. The rule of "speed-tons," demonstrated by Mr. Price Williams, M. Inst. C.E., was adopted as a basis; but it was found that the number of "speed-tons" required to wear out rails was greatly diminished by the weights being concentrated on fewer points. A comparison with a standard was however obtained. The bending of the rail, to form a circle, if done at a dull red heat, did not injure the texture of the iron, but a polygonal arrangement was preferred, to equalise the wear on the rollers. In testing iron rails for strength, some gaps were left in the circle, and the rails laid across unsupported for an interval of 6ft. It was then found that flange rails weighing 76lbs. to the yard did not take any set until the flanges were drilled in the centre with two $\frac{3}{4}$in. holes, and the material cut away from those holes to the edges; and that they did not break until the flanges were cut away so that only $\frac{1}{4}$in. of iron was left in the centre, showing a good margin of strength. The results of testing the wearing properties of eight samples of rails were given in a table, and six pieces of worn rails were exhibited.

Out of four hundred and twenty-seven Bessemer steel rails, of flange pattern, tested for strength, with an interval of 6ft. between the supports, four only broke. The author recommended all steel rails to be tested for strength, as a few brittle ones brought discredit on all, by causing accidents. They could be tested, without stopping the machine, at the rate of from 4 to 5 tons of rails per hour at a single opening, of which there might be three or four in the circle.

A machine of full power, with four rollers pressing with 7 tons each upon the rails, would, if working at a speed of 40 miles per hour, give per day of twenty-two hours, an effect of 41,395,200 speed tons. A few days of such work would determine the qualities of even very good rails.

At the meeting of this society on Tuesday the 4th ult., Mr. Charles B. Vignoles, F.R.S., President, in the chair, eighteen candidates were balloted for and declared to be duly elected, including three members, viz.: Mr. Robert Lunn, Middle Level Drainage, March; Mr. Joseph William Trutch, Commissioner of Lands and Works, and Surveyor-General of British Colombia; and Mr. Henry Wood, Superintending Civil Engineer, H.M. Dockyard, Portsmouth. Fifteen gentlemen were elected associates, viz.: Mr. Henry Brady, Engineer Staff of the London and South Western Railway; Mr. Edward Buckham, Engineer and Surveyor to the Corporation of Maidstone; Mr. Archibald Davis Dawnay, Coal Exchange; Mr. Sydney Gedge, M.A., Old Palace Yard; Mr. George William Goodison, Liverpool; Mr. John Jackson, Wansford, Huntingdonshire; Mr. Christian Hendrick Meijer Contractor's staff, Portsmouth Dockyard Extension Works; Mr. Edwin Muir, Resident Engineer, Rochdale Canal Navigation; Mr Howard Devenish Pearsall, Stud. Inst. C.E. Assistant Engineer, P.W.D., Government of India; Mr. Thomas Mellard Reade, Liverpool; Mr. Campbell Thomson, Assistant Engineer, P.W.D., Government of India; Mr. John Thomson, Dundee; Mr. Robert Vawser, Borough Engineer of Warrington; Mr. James Henry Whittle, Principal Assistant Engineer, Great Southern Railway of Buenos Ayres; and Mr. William Yuill, Assistant Resident Engineer, Breakwater Works, Aberdeen.

The council reported that, acting under the provisions of Sect. IV. of the bye-laws, they had recently admitted Mr. Alfred Henry Hollis, a student of the Institution.

THE Launceston and Western Railway, the first railway ever constructed in Tasmania, was formally opened by his Excellency the Governor in February. Two trains started, containing the Governor, Mrs. Du Cane, the members of the Ministry, members of Parliament, civic representatives, and a large number of shareholders. A grand banquet was held at Launceston in the evening. The line is forty-three miles in length; it connects Launceston with the rich agricultural district of Deloraine, and its whole cost is £450,000.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

EXAMPLES OF THE PERFORMANCE OF THE ELECTRO-MAGNETIC ENGINE.

By. J. P. JOULE, D.C.L., F.R.S.

Some experiments and conclusions I arrived at a quarter of a century ago having been recently criticised, I have thought it might be useful to place the subject of work in connection with electro-magnetism in a different and I hope clearer form than that in which I have hitherto placed it. The numbers given below are derived from recent experiments.

Suppose an electro-magnetic engine to be furnished with fixed permanent steel magnets, and a bar of iron made to revolve between the poles of the steel magnets by reversing the current in its coil of wire. Such an arrangement is, perhaps, the most efficient, as it is the most simple, form of the apparatus. In considering it, we will first suppose the battery to consist of five large Daniell's cells in series, so large that their resistance may be neglected. We will also suppose that the coil of wire on the revolving bar is made of a copper wire 389ft. long, and $\frac{1}{16}$th of an inch diameter, or offering a resistance equal to one BA unit. Then, on connecting the terminals of this wire with the battery, and keeping the engine still, the current through the wire will be such as, with a horizontal force of earth's magnetism 3·678, would be able to deflect the small needle of a galvanometer furnished with a single circle of 1ft. diameter, to the angle of 54° 23′. Also this current going through the above wire for one hour will evolve heat that could raise 110·66lbs. of water 1°, a quantity equal to 85,430ft.-lbs. of work. In the meantime the zinc consumed in the battery will be 535·25 grains. Hence the work due to each grain of zinc is 159·6ft.-lbs., and heat 0·20674 of a unit.

I. In the condition of the engine being kept still we have therefore, current being 1·396, as shown by a deflection of 54° 23′—

1. Heat evolved per hour by the wire, 110·66 units.
2. Consumption of zinc per hour, 535·25 grains.
3. Heat due to 535·25 grains, 110·66 units.
4. Therefore the work per hour will be (110·66 — 110·66) 772 = 0.
5. And the work per grain of zinc will be $\frac{0}{535 \cdot 25} = 0$.

II. If the engine be now started and kept by a proper load to a velocity which reduces the current to $\frac{2}{3}$, or 0·9307, indicated by deflection 42° 57′, we shall have—

1. Heat evolved per hour by the wire, $110 \cdot 66 \times \left\{ \frac{2}{3} \right\}^2 = 49 \cdot 18$ units.
2. Consumption of zinc per hour, $535 \cdot 25 \times \frac{2}{3} = 356 \cdot 83$ grains.
3. Heat due to 356·83 grains, $110 \cdot 66 \times \frac{2}{3} = 73 \cdot 77$ units.
4. Therefore the work per hour will be (73·77 — 49·18) 772 = 18983ft.-lbs.
5. And the work per grain of zinc will be $\frac{18983}{356 \cdot 83} = 53 \cdot 2$, or $\frac{1}{3}$ of the maximum.

III. If the load be lessened until the current is reduced to $\frac{1}{2}$ of the original amount, or to 0·698, we shall have—

1. Heat evolved per hour by the wire $110 \cdot 66 \times (\frac{1}{2})^2 = 27 \cdot 665$ units.
2. Consumption of zinc per hour, $535 \cdot 25 \times \frac{1}{2} = 267 \cdot 62$ grains.
3. Heat due to 267·62 grains $110 \cdot 66 \times \frac{1}{2} = 55 \cdot 33$.
4. Therefore the work per hour will be (55·33 — 27·665) 772 = 21357.
5. And the work per grain of zinc will be $\frac{21357}{267 \cdot 62} = 79 \cdot 8$, or $\frac{1}{2}$ of the maximum duty.

IV. If the load be still further reduced and velocity increased so as to bring down the current to $\frac{1}{3}$ of what it was when the engine was still, or to 0·4653, shown by a deflection of the galvanometer of 24° 57′, we shall have—

1. Heat evolved per hour by the wire $110 \cdot 66 \times (\frac{1}{3})^2 = 12 \cdot 294$ units.
2. Consumption of zinc per hour, $535 \cdot 25 \times \frac{1}{3} = 178 \cdot 42$ grains.
3. Heat due to 178·42 grains, $110 \cdot 66 \times \frac{1}{3} = 36 \cdot 89$ units.
4. Therefore the work per hour will be (36·89 — 12·294) 772 = 18988ft.-lbs.
5. And the work per grain of zinc will be $\frac{18988}{178 \cdot 42} = 106 \cdot 4$, or $\frac{2}{3}$ of the maximum duty.

V. Remove the load still further until the velocity increases so much that the current is brought down to $\frac{1}{100}$th of its quantity when the engine is still. Then we shall have—

1. Heat evolved per hour by the wire, $110 \cdot 66 \times (\frac{1}{100})^2 = 0 \cdot 011066$ of a unit.

2. Consumption of zinc per hour, $535{\cdot}25 \times \frac{1}{100} = 5{\cdot}3525$ grains.
3. Heat due to 5·3525 grains of zinc, $110{\cdot}66 \times \frac{1}{100} = 1{\cdot}1066$ units.
4. Therefore the work per hour will be $(1{\cdot}1066 - 0{\cdot}011066)\ 772 =$ 845·73ft.-lbs.
5. And the work per grain of zinc will be $\frac{845{\cdot}73}{5{\cdot}352} = 158$, or $\frac{99}{100}$ of the maximum duty.

When the velocity increases so that the current vanishes the duty = 159.6.

I. Let us now improve the engine by giving it a coil of four times the conductivity, which will be done by using a copper wire 389ft. long and ⅛th of an inch diameter, the same battery being used as before. Then when the engine is kept still we shall have a current $1{\cdot}396 \times 4 = 5{\cdot}584$, shown by a deflection of 78° 51′. Then we shall have—

1. Heat evolved per hour by the wire, $110{\cdot}66 \times (\frac{4}{2})^2 = 442{\cdot}64$ units.
2. Consumption of zinc per hour $535{\cdot}25 \times 4 = 2141$ grains.
3. Heat due to 2141 grains, 442·64 units.
4. Therefore the work per hour will be $(442{\cdot}64 - 442{\cdot}64)\ 772 = 0$.
5. And the work per grain of zinc will be $\frac{0}{2141} = 0$.

II. Start the engine with such a load as shall reduce the current to ⅔, or to 3·7227 (74° 58′), then we shall have—

1. Heat evolved per hour by the wire, $442{\cdot}64 \times (\frac{2}{3})^2 = 196{\cdot}73$ units.
2. Consumption of zinc per hour, $2141 \times \frac{2}{3} = 1427{\cdot}3$ grains.
3. Heat due to 1427·3 grains, $442{\cdot}64 \times \frac{2}{3} = 295{\cdot}08$ units.
4. Therefore the work per hour will be $(295{\cdot}09 - 196{\cdot}73)\ 772 = 75934$.
5. And the work per grain of zinc will be $\frac{75934}{1427{\cdot}3} = 53{\cdot}2$ or $\frac{1}{3}$ of the maximum duty.

III. Lessen the load so that the velocity of the engine is increased until the current is reduced to one-half its original amount, or 2·792 shown on the galvanometer by a deflection of 70° 18′. Then we shall have—

1. Heat evolved per hour by the wire, $442{\cdot}64 \times (\frac{1}{2})^2 = 110{\cdot}66$ units.
2. Consumption of zinc per hour, $2141 \times \frac{1}{2} = 1070{\cdot}5$ grains.
3. Heat due to 1070·5 grains, $442{\cdot}64 \times \frac{1}{2} = 221{\cdot}32$ units.
4. Therefore the work per hour will be $(221{\cdot}32 - 110{\cdot}66)\ 772 =$ 85430ft.-lbs.
5. And the work per grain of zinc will be $\frac{85429}{1070{\cdot}5} = 79{\cdot}8$, or ½ the maximum duty.

IV. Let the load be further reduced until the velocity reduces the current to ⅓, or to 1·8613 shown by a deflection of 61° 45′. Then we shall have—

1. Heat evolved per hour by the wire, $442{\cdot}64 \times (\frac{1}{3})^2 = 49{\cdot}182$ units.
2. Consumption of zinc per hour, $2141 \times \frac{1}{3} = 713{\cdot}66$ grains.
3. Heat due to 713·66 grains of zinc, $442{\cdot}64 \times \frac{1}{3} = 147{\cdot}55$ units.
4. Therefore the work per hour will be $(147{\cdot}55 - 49{\cdot}182)\ 772 =$ 75940ft.-lbs.
5. And the work per grain of zinc will be $\frac{75940}{713{\cdot}66} = 106{\cdot}4$, or $\frac{2}{3}$ of the maximum.

V. Let the load be still further reduced until, with the increased velocity, the current becomes reduced to $\frac{1}{100}$, or to 0·05584 showing a deflection of 3° 12′. Then we shall have—

1. Heat evolved per hour by the wire, $442{\cdot}64 \times (\frac{1}{100})^2 = 0{\cdot}044264$ of a unit.
2. Consumption of zinc per hour, $2141 \times \frac{1}{100} = 21{\cdot}41$ grains.
3. Heat due to 21·41 grains of zinc, $442{\cdot}64 \times \frac{1}{100} = 4{\cdot}4264$ units.
4. Therefore the work per hour will be $(4{\cdot}4264 - 0{\cdot}04426)\ 772 =$ 3383ft.-lbs.
5. And the work per grain of zinc will be $\frac{3383}{21{\cdot}41} = 158$, or $\frac{99}{100}$ of the maximum duty.

Now suppose that we still further improve our engine by making the stationary magnets twice as powerful. In this case all the figures will remain exactly the same as before, the only difference being that the engine will only require to go at half the velocity in order to reduce the current to the same fraction of its first quantity. The attraction will be doubled, but the velocity being halved no change will take place in the amount of work given out.

In all cases the maximum amount of work per hour is obtained when the engine is going at such a velocity as reduces the current to one-half of its amount when the engine is held stationary; and in this case the duty per grain of zinc is one-half of the theoretical maximum.

The same principles apply equally well when, instead of employing the machine as an engine evolving work, we do work on it by forcibly reversing the direction of its motion. Suppose, for instance, we urge it with this reverse velocity until the quantity of current is quadrupled or becomes 22·336 indicated by a deflection of 87° 26′. Then we shall have—

1. Heat evolved per hour by the wire, $442{\cdot}64 \times 4^2 = 7082{\cdot}2$ units.
2. Consumption of zinc per hour, $2141 \times 4 = 8564$ grains.
3. Heat due to 8564 grains of zinc, $442{\cdot}64 \times 4 = 1770{\cdot}56$ units.
4. Therefore the work per hour will be $(1770{\cdot}56 - 7082{\cdot}2)\ 772 = -$ 4100432ft.-lbs.
5. And the work per grain of zinc will be $\frac{-4100432}{8564} = -478{\cdot}8$ or — three times the maximum working duty.

The principal reason why there has been greater scope for the improvement of the steam engine than for the electro-magnetic engine arises from the circumstance that in the formula $\frac{a-b}{a}$, applied to the steam engine by Thompson, in which a and b are the highest and lowest temperatures, these values are limited by practical difficulties. For a cannot be easily be taken above 459° + 374° = 833 from absolute zero, since that temperature gives 12·425 atmospheres of pressure, nor can b be readily taken at less than the atmospheric temperature or 459° + 60° = 519°. Also there is much difficulty in preventing the escape of heat; whereas the insulation of electricity presents no difficulty.

I had arrived at the theory of the electro-magnetic engine in 1840, in which year I published a paper in the fourth volume of "Sturgeon's Annals," demonstrating that there is "no variation in economy, whatever the arrangement of the conducting metal, or whatever the size of the battery." The experiments of that paper indicate 36ft.-lbs. as the maximum duty for a grain of zinc in a Woollaston battery. Multiplying this by four to bring it to the intensity of a Daniell's battery we obtain 144ft.-lbs. Here, as in the experiments in the paper on "Mechanical Powers of Electro-Magnetism, Steam, and Horses," the actual duty is less than the theoretic; which is owing partly to the pulsatory nature of the current, and partly also to induced currents giving out heat in the substance of the iron cores of the electro-magnets; although these last were obviated as far as possible by using annealed tubes with slits down their sides.

INSTITUTION OF NAVAL ARCHITECTS.

REPORT OF THE COUNCIL.

"The Council of the institution are glad to be able to report to the members and associates that the prospects of the institution are more satisfactory than ever.

"Thanks to care and economy, the institution is now wholly out of debt. Since the preparation of the balance-sheet, every outstanding liability up to the present date has been actually discharged, with the exception of some trifling bills, which have not yet been sent in, but which do not amount in all to £10. The volume of last year has been paid for, and discount allowed for prompt payment, and there is at this moment £250 in the treasurer's hands, besides a small balance in the hands of the honorary secretary.

"The Council desire to express to the members and associates their high sense of the valuable services rendered by Mr. Merrifield, as honorary secretary to the institution, and trust that by the next annual meeting the finances of the institution will enable them to attach a pecuniary compensation to the arduous duties of the secretaryship.

"This satisfactory condition of the finances, to which the Admiralty have again contributed £250, is mainly due to the great care that has been taken to keep down the working expenses. During the past year, the expenses have been kept within the income. The institution possesses a stock of volumes of "Transactions" and a professional library, which is open for the consultation of members and associates.

"The Council are glad to be able to state that the Royal School of Naval Architecture and Marine Engineering is doing successful work. Many of the former students are now filling positions of trust and responsibility, both in the public service and in private employment. Details of their names and present occupations will be found in the "Annual" of the school, a professional magazine which has been originated by the students, and the first number of which is doubtless in the hands of many of the members and associates of the institution.

"The Council directed the issue of a circular, pointing out certain subjects on which they desired to receive communications. A very large

number were issued, but only produced a limited number of replies. This circular has, however, had the effect of giving a somewhat more varied character to the programme of papers to be read at the present meeting than it would probably otherwise have had."

Sir John Pakington, Bart. (President), said:—Gentlemen,—It now becomes my duty to commence the business of this annual meeting by addressing to you some few observations, as I have the honour to be your chairman, but I feel on this occasion, as I have on other occasions, that I should best perform that duty by compressing those observations within as narrow limits as I fairly can, in order that any address from me may not interfere with those more important proceedings which will occupy the remainder of our time. Many years have now slipped away since you first did me the honour of placing me in this chair; and I can only say that which I think every man would naturally feel, that I cannot have held this distinguished position so long without feeling a growing attachment, I may say growing interest, in the welfare and progress of this institution; and every year tends more and more to convince me that, looking to those great national objects which we have in view, the working and the operation of this institution has been most successful and most valuable, and it is a matter of legitimate congratulation, and upon which I do congratulate every member of this institution, whom I have now the honour of addressing, that the contents of the report are of that favourable character to which we have listened this morning. We find, from the contents of that report, not only that the usefulness of this institution continues, not only that its success is undoubted, but, for the first time, I am happy to say, you have received a most satisfactory report with regard to the financial prosperity of this institution. It is now fairly launched. There have been some difficulties in former days to contend with, but they have now been overcome, and we may, I think, with greater confidence than at any former period, congratulate ourselves upon the established success and the steady prosperity of this valuable institution. Not only are our finances in a prosperous condition, but our numbers are steadily increasing. And, gentlemen, there is another point in this report, on a subject by no means new to us, but which we have never been able before to advert to in the same terms as we now do. I allude to the continued success of the Royal School of Naval Architecture, which I may speak of, I think, as I have done before—as the child of this institution, and which has now been carrying on its work till we can speak in terms such as we never could before use—namely, those which you have heard from the report, that "many of the former students are now filling positions of trust and responsibility both in the public service and in private employment." I heartily congratulate you on this consummation of that part of our work. I have always regarded that part of our work with peculiar interest, because I have felt its national importance, and we are now reaping the first and real fruits of the success of that part of our institution. Gentlemen, there is another paragraph in the report to which I cannot help calling your special attention, and I feel it the more my duty to do so because I am sure you will not fail to have observed that, distinct as our secretary generally is in all that he says he did not read this paragraph of the report with that emphasis and care with which he generally reads other paragraphs:—"The Council desire to express to the members and associates their high sense of the valuable services rendered by Mr. Merrifield as honorary secretary to the institution, and trust that by the next annual meeting the finances of the institution will enable them to attach a pecuniary compensation to the arduous duties of the secretaryship." I am sure I do not say too much when I add that those duties have been discharged in a manner to entitle our friend Mr. Merrifield to the gratitude of every one who takes an interest in this institution, and I hope, before we meet again another year, we shall be in a position, as that paragraph indicates, to afford him a more substantial and better proof of our feeling on that subject. There is one subject, gentlemen, to which I am obliged to advert in terms of regret—it is the circumstance which has compelled us to adopt what is, in one respect, a retrograde movement. It will be in the recollection of everyone here that last year, such was the growing interest of our institution, and so great was the amount and importance of the matter to be brought before us, that we extended our proceedings over four days instead of three, but this hall in which we are now assembled is, as you are aware, occupied on Wednesday in every week by the Society of Arts; and last year, on the first day of our meeting, we were kindly allowed the use of the theatre at South Kensington, by which we gained the Wednesday, so that we were able to hold our meetings on four successive days instead of three. This year it was intended to carry out that arrangement again, but we were obliged to abandon that intention in consequence of the public proceedings which took place yesterday, at Kensington, in connection with the opening of the Albert Hall. That compelled us to fall back again upon our old limit of three days; but I think, when you look at the business programme, and at the number of the papers that are to be read, it will afford abundant proof that if we could have occupied four days we should have had ample matter for doing so. I very much regret that we could not repeat the arrangements of last year, owing to the causes to which I have adverted; but I hope that next year we shall again return to the four days' meetings instead of three. Gentlemen, in these nautical matters, as in others, science does not stand still. We have abundant proof of that on every side, and we have the satisfaction of finding that while science is advancing in a variety of ways, this institution enables us to draw together the many proofs of those advances in science, and here to discuss and consider, and permanently to record the various changes that take place, and thus to fulfil the useful and valuable mission which I consider to be the function and immediate duty of this association. It would not be for me, even if I were competent, which I am not, to enter into the various respects in which those various branches of science relating to our particular duties are progressing and advancing; but I cannot help briefly glancing at the changes which are taking place with regard, for instance, to improvements in steel, and the extent to which it seems probable that, at no distant day, steel, to a certain extent, at all events, will supersede the use of iron. Simultaneously with those changes with regard to steel, we find the manufacture of iron is also being greatly changed and greatly improved, and it is impossible to regard with indifference the improvements in these metals, bearing, as they inevitably will in an important degree, upon the construction of our ships in future days. Other great changes have taken place with regard to the manufacture of marine engines, and I am exceedingly glad that we made that change last year of admitting marine engineers as members, as they ought to be most fitly, of this association. I think it was a most desirable and beneficial change, and that in many ways we are reaping the benefit of it: and if I may believe and trust what I hear, I believe the marine engines of the present day are almost as different from the marine engines which were placed in vessels when they were first propelled by steam as those engines were from the unassisted canvas. Such is the progress of science, and that progress is continuous and uninterrupted. Gentlemen, there is another subject to which I think it my duty briefly to refer. It will be in the recollection of many who are here, that when I made my opening address at this institution last year, I adverted to several melancholy cases which had arisen of the loss of ships at sea. I remember stating to the meeting that having thought it my duty to put certain questions on the subject in the House of Commons, I had received from all parts of the country communications of such deep interest, and tending to excite such vague suspicions and doubt as to the state in which many of our merchant vessels are sent to sea, that I thought it my duty to consult this institution as to whether, in their judgment, the time had not arrived when it would be desirable to raise some question upon this subject in the House of Commons. The opinion of the meeting was that the subject did require parliamentary attention, and I think it my duty, therefore, to mention to the institution that, in furtherance of what I understood to be the wish and request of my brother members of the institution, I did call the attention of the House of Commons to the subject, and moved a resolution praying, in substance, that a commission should be issued to inquire into the cause of the great loss of life and property at sea during the last few years, and to inquire if any and what changes could be made with respect to collisions, over-loading, stowage of cargo, and other matters with a view of giving increased safety to passengers and merchant ships. That resolution I moved in the House of Commons, and a debate, I think I may say of considerable interest, took place, the result being that I did not find it desirable to divide the House on the subject, and in consequence of the turn which the debate took I withdrew the motion, but with an intimation that the subject would not be considered as being at an end; and I am willing to hope that, even as matters now stand, that discussion was not altogether without satisfactory results and some fruits. This year the subject has been again mentioned in Parliament by another honourable member, and some little discussion upon the matter took place. We have again before us that huge Mercantile Marine Bill—a great volume, in fact—which was brought forward last year. I cannot say I have read all the numerous pages of that tremendous bill, but I believe it is essentially much the same bill as that of last year. I think the general impression last year in the House of Commons was, and I believe the general impression among those conversant with the subject was, that the provisions contained in that bill for the correction of those evils to which I have now adverted were not altogether satisfactory. That is, I think, still the impression of those who have considered this subject, and it is satisfactory to be able to state that, in the discussion that took place, the present president of the Board of Trade was strongly pressed, in the event of the business of the session being such as not to allow a full discussion of the great Mercantile Marine Bill, to embody that particular portion of the bill which relates to the safety of ships at sea in a separate measure, and bring it forward during the present session under such circumstances as to allow Parliament fairly to discuss a ques-

tion so important to the lives of our sailors and the property of our shippers. That is the position in which the case now stands. Of course, it will be the duty of those who take an interest in this subject—and I am happy to see some gentlemen among us here who are members of Parliament—to remind the President of the Board of Trade of the promise which he has made, and I am sanguine enough to hope that the Session will not pass without the attention of the House being called to this subject. I cannot say, gentlemen, that I am familiar, at this moment with the statistics of our losses at sea during the time that has intervened since last year. Whenever I make myself master of those statistics, I think it very probable I may find that, at all events, those casualties which arise from blamable causes have not been so numerous as last year, because I think it probable that the discussions in Parliament last year would act as a warning to those who might have been in need of any such warning. I hope and trust we shall hear of no more *Sea Queens* in the present year, and I trust, however that may be, or whatever may be the statistics of last year, and however favourable they may appear—whether they are favourable or not I really do not know—that Parliament will not be diverted from giving serious attention to this subject, which I myself entirely and fully believe to be necessary. Gentlemen, I think I might here end the observations that I think it my duty to make to you to-day, were it not for one painful subject, which I feel it to be impossible for me to pass over in silence—I allude to that terrible event which cast a gloom over the whole of this country, the loss of her Majesty's ship *Captain*. Gentlemen, I, perhaps, more than most people, have peculiar reason for regarding that subject with the greatest interest. I was not only personally a sufferer, by the loss of a very near connection, who was as promising a young man as ever entered the naval profession, but the share which it was my official duty to take in the construction of that ship has also made me feel a peculiar interest in the subject, and of course has cause me to watch her short career with unusual care and with unusual interest. It so happened, that in point of form, rather than in point of fact, I think I may say, it devolved on me to order the construction of the ship. When I was appointed First Lord of the Admiralty, in the summer of 1866, the position of things which I found was this:—The public mind had been a long time anxiously attending to the suggestions of the unfortunate and ill-fated Captain Coles with regard to this subject. He was a very able man, as we all know, and he had invented what he thought, and I believe rightly thought, a very great invention—a great improvement in the construction of our war ships. He had pressed those views upon successive Boards of Admiralty, and in deference, I think I may say, to those views so urged by Captain Coles, Her Majesty's Government, through the Admiralty, presided over by the Duke of Somerset, had built the *Monarch* as a ship intended to meet the view of Captain Coles, and to solve the great practical problem which had been pressed so much by Captain Coles, namely, that a turret ship might be built as a cruiser. Nobody doubted the possibility of using turret ships for coast defence, but the real problem was whether a turret ship could be a cruising man of war. The *Monarch* was built to solve that problem. But Captain Coles would not accept the *Monarch* as a satisfactory solution of his problem. He took great objection (but I will not detain this meeting by dwelling on the points to which he objected) in several respects to the construction of the *Monarch*, and before the Duke Somerset left office, he decided, and I venture to say wisely and rightly, to call upon Captain Coles to submit his views to the Admiralty, with an understanding that he might select one of our great ship-building firms and build a ship according to his own views; and I think out of a list of six (speaking from memory, I think it was before the Duke of Somerset left office), with the concurrence of the then Board of Admiralty, Captain Coles decided to entrust the building of that ship to the well-known and highly-respected firm of Messrs. Laird, of Birkenhead. It then devolved upon me, after succeeding the Duke of Somerset, to carry out this intention, which I was most thoroughly disposed to do, because I thought it right that the great question raised by Captain Coles should be fairly solved; and in an interview with Captain Coles, in the name of the then existing Board of Admiralty, I told him to persevere, to build his ship, and I entirely approved of the selection of the Messrs. Laird, as being the best persons to whom he could entrust that duty, and I required that the designs and plans which he intended to adopt should be submitted to the then Board of Admiralty which was acting under me. Well, gentlemen, Captain Coles shortly afterwards brought his designs and his plans, and showed us a ship which was to be upwards of 300ft. in length, which was to be upwards of 4,000 tons in size, but which was to have a free-board of only 8ft. In a private conversation in my room at the Admiralty with Captain Coles, I shrunk very much from this free-board of 8ft. It will be in the recollection of most of you, after I brought forward that melancholy event, the loss of the *London*, that the Council of this Institution undertook, and in a manner which I have always thought greatly to their honour, carried out, an investigation into the various modes of constructing sea-going ships, and I think they arrived at the conclusion that 8ft. free-board was the very minimum which could be safely assigned to a ship of anything like the dimensions to which I have adverted; but considering the construction of a man-of-war, and considering the weights of various kinds that she has to carry, I confess it was with great reluctance that I consented to a free-board of 8ft., but I did consent to it on this ground that the principle on which I was acting was that Captain Coles should solve his own problem, and that, as he pressed to have a ship with that free-board, it would not have been consistent with the principles on which I was acting to interfere further than to express my doubts and fears with regard to the success or so low a free-board. Gentlemen, you know the result—the ship was proceeded with, the ship was launched, and, to the astonishment of everyone, I think—and I confess I can never forget the dismay with which I heard it—instead of a free-board of 8ft., the *Captain* was launched with a free-board of only six feet.

Mr. Merrifield—6ft. 5in.

The Chairman—My friend Mr. Merrifield says it was 6ft. 5in. I have intentionally dropped the five inches. I think the original free-board suggested to me was more than 8ft.; I fancy it was 8ft. 4in. I am taking the broad figures. The real distinction was between 8ft. and 6ft., but there were odd inches, if I remember rightly, in both cases. The real distinction was a free-board of 8ft. proposed, a free-board of 6ft. really. Those were the facts. Gentlemen, you must all feel that this serious deviation from the design of the ship has led to many grave questions, and will lead probably to many more grave questions. Such questions as these have arisen, and must arise. What was the cause of the great deviation from the original design? Was that deviation from the original design the cause of the loss of the *Captain?* That is another question. A third question is—When that great deviation from the design was discovered, what steps were taken? Were proper steps taken to test the effect of that deviation on the stability of the ship? If no such steps were taken, why were they not taken, and who was to blame? Gentlemen, I have just mentioned some of the questions which have arisen, and which must arise in every mind, upon this most painful subject; but with regard to these questions which I have just suggested, it is not my intention to say one single word, and if I may take the liberty from this chair of offering advice to my brother members of this institution, I would venture strongly to counsel that we should not enter into discussions of any personal matters. I think that we should be travelling out of our way if we were to do so. We should be raising questions which we are not able to settle, and we might be giving pain in many quarters without being at all competent to decide how far or where that pain ought really to be inflicted. Above all, gentlemen, I would counsel you, if you will permit me to take the liberty of doing so, to bear in mind that these are questions still pending. They are questions which may, and, indeed, as far as I have the means of judging at this moment, probably will, become the subject of discussion in Parliament; therefore I would strongly urge that we should not introduce them upon this occasion. We cannot settle them; they are questions no doubt of extreme interest, but whether we discuss them or whether we do not, and whether they come before Parliament or whether they do not, I think we may console ourselves with this one only subject of consolation which a subject so painful can afford. Depend upon it the lessen we have had will not be thrown away, and, wherever the blame may rest, that blame will not be incurred again. I hope, gentlemen, I have not exceeded the limits of my duty in venturing to offer this advice. With regard to any scientific questions which may arise, or with regard to any scientific inferences which may be drawn from the construction of that ship, I hold that as a matter of naval architecture, as a matter of scientific inquiry, it is not at all desirable that we should exclude this subject, painful as it is, but that we, exercising our proper and legitimate functions, should endeavour to draw from that unhappy calamity whatever useful inferences and sources of instruction we may be enabled to do; but, gentlemen, I hope that you will subscribe to the propriety of my earnest advice, that we should abstain from the discussion of every question of a personal nature in connection with this very painful subject.

ON STEEL AS APPLIED TO SHIPBUILDING.

By J. B. Howell, Esq., Associate.

In the year 1853, I called the attention of shipbuilders and engineers generally to the value of mild cast-steel, as a material especially adapted for shipbuilding and kindred purposes, and for a long time I failed to make any valuable impression upon those I thought most likely to entertain the subject. I was not merely unsuccessful, but I found, in many instances, a positive aversion to the use of steel for constructive purposes. This aversion, I have no doubt, was caused by the habitual thought of public opinion respecting steel being synonymous with

brittleness. Finding this objection so constantly occurring, it suggested to my mind the necessity of giving it another name, and after about two years of fruitless effort, I introduced it as "Howell's Homogeneous Metal." This was the origin of the successful application of steel for boilers, tubes, ships, and locomotive fire-boxes. Messrs. Laird, of Birkenhead, constructed the little vessel called the *Ma Robert*, for the Livingstone expedition. This is the first instance of the application of steel for shipbuilding; but since that time, mild cast-steel has been used very extensively for this and other purposes, where strength and lightness is a first consideration. We are now enabled to make steel suitable in the highest degree for shipbuilding, and I beg to call your attention to the samples exhibited. All these samples have been bent cold, which is a simple and safe test for steel plates; and some of them, before bending, have been heated to a red heat and plunged into cold water, which is a doubly sure test; these particular pieces are marked "A," but they do not appear to have suffered from the severe ordeal they have passed through. The samples are bent, to show the angles to which the various thicknesses of plates should be bent, as a proof of their suitability for ship plates. The extreme test of 180° is beyond the necessary test for plates of this character, but plates up to a ½in. in thickness should always bear bending to that degree. The steel may be easily sheared, punched, caulked, and welded, and is 50 per cent. more rigid than iron. The term steel can barely be applied to this metal, as the very small amount of carbon it contains would prevent its being put in the same category as steel. The samples on the table contain 0·2 per cent. of carbon. This, I consider should be the maximum quantity of carbon in steel intended for shipbuilding; for all plates containing this quantity of carbon never fail to give the required tests practically. We have discovered, in our long and extensive experience, certain irons as being the most suitable for the manufacture of these plates, and as there is no reasonable limit to the supply of these irons, there is no difficulty in turning out large quantities of these plates regular in their manufacture. The strength in tension of this steel is about 36 tons per square inch, and the limit of elasticity about 23 tons. From this, it can be seen that the rigidity of mild cast-steel is nearly two-thirds of its ultimate breaking strain. Steel is, beyond doubt, stronger than iron; it is much stiffer, and far more ductile; and I think, were it used only for the skeleton of ships plated with iron, it would be a great gain in strength and stiffness of the whole structure.

Steel plates of 1in. and less in thickness will resist the impact of shot much better than iron. During the experiments at Shoeburyness, conducted by the Iron Plate Committee, and referred to by Sir William Fairbairn in the "Transactions" of the tenth session of this institution, steel plates ½in. thick were found to have a resistance equal to iron plates ⅞in. thick, and steel plates ¾in. thick were equal to iron 1in. thick, and steel plates 1in. thick had a resistance exceeding iron plates 1¼in. thick, but not equalling iron plates 1½in. thick. The steel plates 2½in. and 3in. thick had no value against the impact of shot, and the first shot in each instance shattered the plates. This result we were quite prepared to expect, as our mechanical appliances were not equal to the successful manufacture of large, thick plates. To ensure ductility in mild steel plates, we require a blow or squeeze sufficiently great to change the granular structure of the cast metal, so that, when broken by tension, it has a conchoidal fracture, or, as it is understood in the trade, knock fibre into it. The market price of these plates, also angles and bars, is from £25 to £30 per ton; a price, I think, sufficiently low to create a demand for them; for although it may seem a large price compared with ordinary ship-plate iron, it will be found economical to use it, not only in the durability of the ship and in repairs, but in the greater safety to life and cargo.

Many persons who have used steel for constructive purposes have even now a great objection to it. This has entirely arisen from inferior and irregular manufacture, due as much to the consumer as the maker, for the cupidity of both has in many instances induced the adoption of a low-priced article, which has failed to give satisfaction. Had manufacturers been careful to see that plates had what I consider the requisite characteristics for constructive purposes, and which are not difficult to determine, I believe the steel of to-day would not only be the future of iron, as Mr. Scott Russell has said on a former occasion, but had the proper precaution been taken in selecting the proper material, the steel of the past would have been the present of iron. It is desirable, where convenient, that the drill should be used instead of the punch in perforating the rivet-holes in all steel plates; and I would further advise that, as soon as possible after their manufacture, they should be well payed, and, where convenient, submerged in boiling linseed oil. I have found in my experience that plates thus coated, after three years' exposure to the weather, have not shown the slighest tendency to corrosion, though subjected to alternate wet and dry. I consider the life of the plates will be lengthened greatly by this process, and the plates will take the paint much better after it. It is most important that destructive oxidation should be avoided as much as possible. The newly-formed oxide arising from the heat of the furnace does not decay until exposed. The oxide formed on steel plates in the fire is much more tenacious than that formed on iron, and forms more completely part of the plate, being difficult to remove without exposure or abrasion.

I have carefully avoided drawing comparisons between different qualities and makes of steel, but have confined myself to a steel which I consider the most suitable for ship-building, taking into consideration the most suitable material, and keeping within the price that I conceive may be paid to make it commercially profitable. Where great strength is required, irrespective of cost, then I should recommend steel such as the armour-plates referred to earlier in my paper, the breaking strain of which, under tension, is 46 tons to the square inch. I would on no account, as far as my experience enables me to judge, use a steel of higher tensile strength than this, as every ton gained in strength beyond this limit is at the cost of ductility, which is important in all structures that are liable to sudden concussion; not but that you can get steel of higher tension with great ductility, but 40 tons is within the limit of certainty. The limit of elasticity of this steel is 30 tons per square inch. This quality of plates is extensively used for locomotive fire-boxes, a great number of which are now in use on the Scottish Central Railway, giving the fullest satisfaction; some, indeed, have been working upwards of nine years. The market price of these plates is £40 per ton, a price which has always prevented shipbuilders from entertaining the idea of using them for shipbuilding.

ON THE WORKING EXPENSES OF STEAMERS OF SMALL SIZE.

By A. F. Yarrow, Esq.

Steam launches have for several years been extensively adopted in Norway and Sweden, carrying on there successfully the traffic across the many estuaries and fiords formed by a very irregular coast line. It is, however, only within a comparatively recent period that these little craft have become generally known in this country. To identify more particularly the type of boat I am now referring to, I may mention that they vary from 30ft. to 60ft. in length, and from 6ft. to 12ft. in beam, generally have no deck, and are propelled mostly by one, but occasionally by two screws, driven by high-pressure direct-acting engines. The time allotted will not admit of my dealing so fully with the subject as I should have wished, I will therefore confine myself to touching briefly upon one or two points of interest. One of the first successful attempts made in this country to develop passenger traffic by boats of this type was started at Plymouth in 1869. A small company was formed, called the Oreston Steamboat Company, with a view to run between Plymouth and Oreston, calling at Hooe, Turnchapel, and Mount Batten, the only communication at the time being by watermen's boats, or a three-mile walk and a toll of 1d. The first steamer purchased was called the *Little Pet*, it was 40ft. in length by 7ft. 6in. beam. The success of this boat induced the company to order another (which was called the *Favourite*), 50ft. in length by 10ft. beam, driven by a pair of 5½in. cylinders, and licensed by the Board of Trade to carry eighty-four persons. The average time occupied by this boat in the run of 1¾ miles, was fifteen minutes including stoppages, and the fare charged 1d. There was no deck whatever, but a cabin the full width of the boat, and 10ft. in length, was provided aft. The draught of water, when at work, was 3ft. with a speed, over a straight course, of 8 to 9 miles an hour. To show more clearly the exact nature of the traffic carried on, I beg your reference to the rough map of Plymouth (exhibited). At the Barbican Pier, the boats run alongside the quay, and at Oreston, there is a small jetty; but at Hooe, Turnchapel, and Mount Batten the boats are gently run on to the beach, and a plank thrown out forward for the outgoing and incoming passengers. This simple means appears to answer the requirements of the case, and the boats, which are strongly built of wood, and suitably shaped to take the ground, do not materially suffer. A considerable business is done in taking off and putting on board passengers from the vessels laying at the anchorage in the Catwater; and if hailed from the shore, the boats are frequently beached to take people up. Gained from the experience of this company, the cost of working such a launch as the *Favourite*, running 24 journeys per day of twelve hours, each journey being 1¾ miles, it has been found that the consumption of fuel has been 8 cwt. per day, and the consumption of fresh water, 350 gallons per day. I may here mention that water tanks are fitted to this boat sufficient for four hours' constant steaming, these tanks being replenished from time to time by the hose at the quay. The crew consist of a captain, receiving 24s. per week, engine driver 21s.

per week, and a collector 18s. per week. These and other expenses I have tabulated, as will be seen subjoined :—

	Per week. £	s.	d.
Interest on first cost, say £550 at 5 per cent. per annum	0	10	7
Fuel $2\frac{3}{4}$ tons per week of 7 days, at 17s. ...	2	6	9
Water 2,450 gallons	0	5	0
Captain	1	4	0
Engine driver	1	1	0
Collector	0	18	0
Repairs, say 15 per cent. per annum	1	11	9
Renewal fund, say $7\frac{1}{2}$ per cent. per annum	0	15	10
Total working expenses per week	£8	12	11

This company has attained considerable success ; the credit for which is mainly due to Mr. Edmund Jones, a resident of Plymouth, who writes as follows :—" During the past summer, each of the three boats has earned occasionally as much as £20 per week, and the opposition company, who have also three boats, nearly as much. The cost of repairs, however, is very heavy ; the watermen, who show a most determined hatred to the boats, do much injury ; and for a long time we had always to keep a watchman on board to guard against malicious damage ; and what with racing with the opposition and consequent coal-wasting, law suits, summonses from the watermen whenever we by chance carried over our legal number, we have had a tough lot of battling, gaining by paying dearly valuable experience. During the last dry summer the fresh water supply ran short, which caused much injury to the boilers from want of sufficient care in constantly blowing off, to prevent incrustation when feeding from the sea. The boats, however, after paying for all this, as well as putting by towards renewal fund, have given a very good profit."

We will now just glance at quite a different style of steamer, one which I have specially selected as doubtless familiar to us all ; I refer to those running on the Thames between London and Westminster Bridges and intermediate piers. They average 110ft. in length by 14ft. beam, being certified to carry 370 passengers, and are propelled by condensing paddle engines of 24 horse-power nominal. To give some idea of the cost of working such a steamer, I have tabulated the expenses, as will be seen subjoined :—

	Per week. £	s.	d.
Interest on first cost, say £2,800 at 5 per cent. per annum	2	13	10
Fuel $8\frac{1}{2}$ tons per week of 7 days at 17s	7	4	6
Captain	2	5	0
Mate	1	10	0
Two men at 22s. 6d. each	2	5	0
One lad	0	8	0
Engineer	2	2	0
Stoker	1	8	0
Repairs, say $12\frac{1}{2}$ per cent. per annum	6	14	7
Renewal fund, say 5 per cent. per annum ...	2	13	10
Total working expenses per week	£29	4	9

These boats are of their type doubtless well designed and ably managed, but I contend that they are unsuited for the work to be performed. Boats of smaller size, such for example as the one I have briefly described, would in my opinion fulfil the requirements of the case much better. They could be more numerous, leaving the piers more frequently ; they would be much more easily handled and brought up alongside the landing stages ; a very much smaller original outlay would be requisite, as well as greatly reduced working expenses. I will admit that during certain hours of the day in fine weather in the summer months, the present steamers will occasionally have their full complement of passengers ; but it is clearly an error to entail excessive working expenses during the whole year, for the sake of rendering available the maximum traffic during a very limited period. When running in fresh water on lakes or rivers, the extreme simplicity of the ordinary type of steam launch enables it to be worked with perfect safety and success, by any one of moderate intelligence and care ; but when used at sea, where salt water only can be obtained for the supply of the boiler, the difficulties are greatly augmented, owing to the risk entailed from incrustation and eventual destruction of the boiler. Whatever care may be requisite on board ocean steamers worked by thoroughly competent men, even still greater care is required with high-pressure engines, the boilers adopted as a rule having much greater evaporative power in proportion to their contents. With the aid of the salinometer, the amount of brine requisite to be blown off to prevent salting up can be carefully regulated, and the boiler preserved for many years in perfectly good condition. This, however, requires an amount of care and attention which experience has proved to be most difficult to obtain even in this country ; and abroad, in places where skilled in labour is scarce, it is sometimes simply impossible. In all cases where a supply of fresh water can be procured on shore, it is unquestionably desirable to have tanks fitted on board from which to feed the boiler, and if these tanks hold sufficient to last until they can be replenished, the boat can be worked without any special care. The use of the ordinary surface condenser is one mode of obtaining a supply of fresh water ; but the great complication of such means is a serious barrier to its adoption, sacrificing at once the marked feature of the steam launch, which is its simplicity, in addition to increasing the cost, and depriving the boiler of the benefit of the blast up the chimney.

It has frequently been proposed, and even tried, to condense the steam by passing the exhaust pipe along the outside of the boat, the external surface coming in contact with the water, and thereby condensing the steam within. I am not aware of any trials of this kind which have proved successful until the middle of last year, when Mr. Alexander Crichton, of Cork, fitted two Government steam launches with such apparatus.* These launches were of the well-known twin-screw type, having two cylinders to each screw secured to the sides of locomotive boilers. The exhaust pipes were passed through the boat's bottom, and carried alongside the keel for 14ft., and then, returning 16ft., re-entered the boat, and were at once connected to two small air pumps worked by eccentrics. These air pumps delivered into a hot well, to which the suction of the feed pumps was attached. Under these circumstances, the whole of the exhaust steam was condensed, and returned to the boiler as fresh water, the only loss worthy of notice being that due to the steam jet, which had to be kept going in the funnel to maintain the requisite draft. In both these launches there appeared to be a considerable gain both in power indicated as well as in speed. The capacity of the air pumps, which were single-acting, was one-twentieth the capacity of the cylinders. There can be no possible doubt that if these results can be confirmed over a lengthened period, that they are indeed most valuable, and great credit is due to Mr. Crichton. We ourselves last month tried some experiments in the same direction, with a small wooden tug boat we have just completed for the Brazils, in which it was a most essential point to carry water and fuel for as many hours as possible. The boat was 37ft. in length, 9ft. in beam, and 5ft. in depth. The engine consisted of a single cylinder $9\frac{1}{2}$in. in diameter by 12in. stroke, and the boiler of the usual return tube type. As the boat was small for the weight of machinery, there was not buoyancy left sufficient to carry the desired quantity of fresh water. We therefore considered this a specially favourable instance for testing the merits of this system. All we were anxious to do was to secure the return of the bulk of the water to the boiler, at the same time retaining amply sufficient blast. To fully explain what was done, I beg your reference to Figs. 1 and 2.

The exhaust pipe was passed to the forward end of the boat, terminating in a breeches piece, which went through the skin on each side of the keel ; to this were secured two 3in. copper pipes, each 21ft. long, running along the boat's bottom towards the stern ; at the after end of these pipes was attached another breeches piece, which re-entered the boat, and was connected to the suction of a small plunger pump, $1\frac{3}{4}$in. diameter by 6in. stroke, worked by an eccentric from the screw shaft as shown. This pump delivered into tanks placed on each side the boat. The inclination of the condensing tubes, when the boat was running, was about $\frac{3}{8}$ths of an inch to the foot. We provided means for conducting the exhaust either wholly up the chimney, or partially into the chimney, and partially into the condensing tubes, always retaining ample collective area for the steam to pass through, which was never less than equal to an orifice of $2\frac{1}{4}$in. diameter. Over a lengthened trial the following were the results obtained.

Consumption of Midland coal per hour, 120 lb. ; evaporation of water, 780 lb. ; pressure of steam per square inch, 54 lb. : estimated indicated horse-power, $20\frac{1}{2}$; revolutions per minute, 120. Under these circumstances we found three-fourths of the steam could be condensed without apparently injuring the draft, the remaining one-fourth passing up the funnel :—The exact quantity of water delivered back into the tank was, per hour, 580 lb. ; the temperature of water in the river being, 44° ; the temperature of water pumped from condensing tubes, 59. The following will be the practical bearings of these results :—Presuming the tanks and boiler to be filled with fresh water, and worked in the ordinary way, the tanks, which contain 320 gallons, will be emptied after, 4 hrs. steaming ; if the condensing apparatus be at work they will be emptied after 16 hrs. steaming.

We will now assume that after the expiration of these times we are forced from necessity to pump from the sea, and we will also assume that the water in the boiler must never have in solution more than $\frac{1}{35}$ its weight of salt, and that up to that time there is no fear of incrustation.

The boiler contains about 1 ton of water, and as the sea holds in

* A plate and full description of the above appeared in The Artizan of July 1st, 1870.

solution $\frac{1}{33}$ its weight of salt, it is clear that 3 tons of water must be evaporated and replaced by 3 tons of sea water before $\frac{3}{33}$ of salt will be present in the boiler. This would occupy in the ordinary way, $8\frac{1}{2}$ hrs. additional; if with condensing apparatus at work, 34 hrs. additional.

I will now bring my paper to a close, and trust I have succeeded in showing what are the probable working expenses of steamers of small size, and in pointing out one of the means by which an important cause of failure and expense may be avoided, or at any rate materially reduced.

FIG. 1.

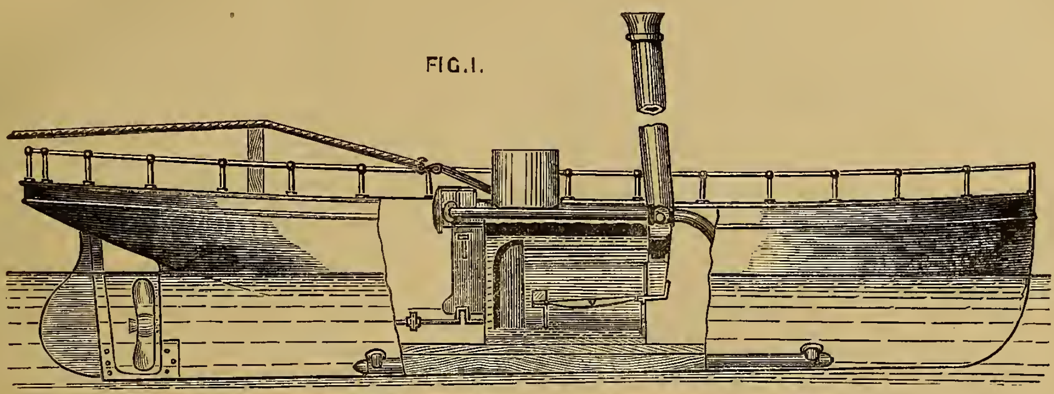


FIG. 2.

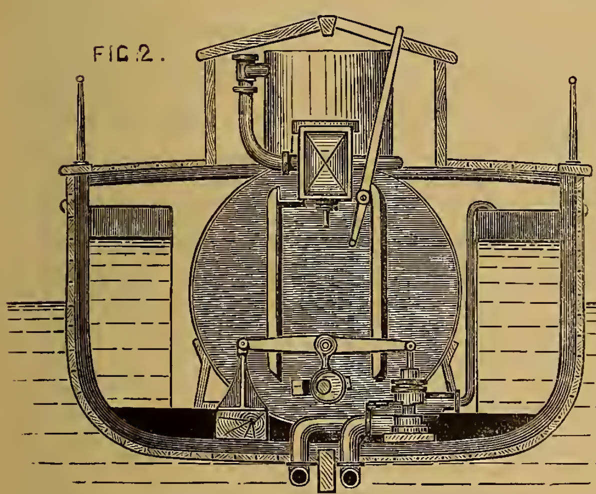
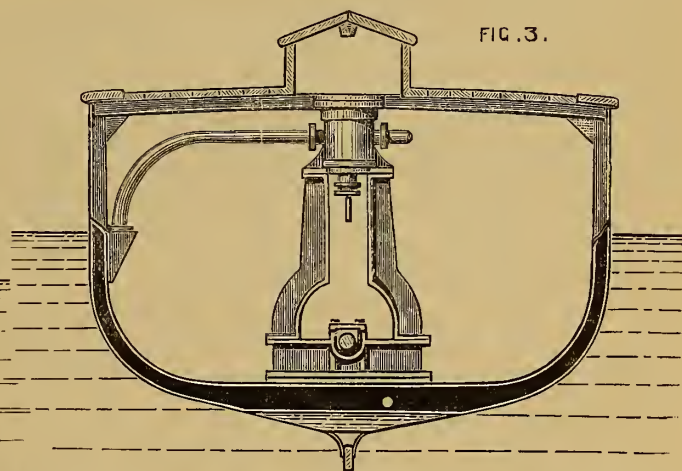


FIG. 3.



We therefore finally arrive at the fact that the total length of time the boiler can be worked with perfect safety from first starting, without risk of incrustation, will be:—

With fresh-water tanks only, $12\frac{1}{2}$ hrs.; if with condensing apparatus, 50 hrs.

For the sake of comparison I have added the time that it would require if salt water only were used for the boiler, for it to arrive at the same degree of saturation: this could be attained after the evaporation of 2 tons of water, which would occupy $5\frac{3}{4}$ hours. I will make no remark on these figures; the practical results are clear without further comment.

The boat upon which these experiments were tried was of wood, but had it been of iron the condensation of the exhaust steam would have been even more readily effected, the condensing pipes would have been quite unnecessary, the skin of the boat itself serving equally well as the conducting medium. To illustrate one practical method of carrying this out, I beg your reference to Fig. 3. That portion of the exhaust to be condensed would be passed into a receiver of which the skin of the boat would form its external side, assuming the frames of the boat to be 18in. apart, ample area would be obtained if the space between three frames be taken, and from the water level on the other side, this would not only form a suitable reservoir for receiving and condensing the steam, but would give additional stiffness to the hull at the very place required, as well as serve as a substantial platform for the engine. The feed pump could take its suction, as shown, and force direct into the boiler, no additional pump being required. As to whether this plan is capable of extensive adoption (which I firmly believe), is is not for me now to enter; but it is certain the required end is obtained at a nominal cost, and without additional complication.

ON THE IMPROVEMENT OF THE CHANNEL SERVICE BETWEEN FOLKESTONE AND BOULOGNE, AND THE VESSELS PROPOSED TO BE EMPLOYED.

By Michael Scott, Esq., M. Inst. C.E.

On the present occasion the author proposes to confine his observations to the Folkestone and Boulogne route. It may reasonably be inferred that one effect of the recent disastrous war will be to postpone, perhaps for many years, the expenditure of large sums on local improvements in France. If so, it will be vain to expect that deep-water harbours should be constructed on the French coast, for the purpose of improving the communication with England. And it may be assumed that the formation of a deep-water harbour on the French coast would necessarily involve the construction of very costly fortifications for its defence; and, having regard to the present exigencies of the national exchequer, and to the financial condition which is likely to obtain for many a year, it does not seem probable that the French government would care to undertake such works. Beyond this, the author holds that, even were the money forthcoming, the period is still distant when the traffic could be expected to yield an adequate return on a large additional outlay. On the threshold of the inquiry it will be necessary to discuss the necessity or otherwise of such service being at fixed hours, independent of tide or weather. For the mails, fixed hours are no doubt essential, but Folkestone and Boulogne are not the mail ports and it has been affirmed that a comparatively minor expenditure would render the mail service quite regular between Dover and Calais. For passengers, it might be said that, being independent of tide, the most convenient hours might be fixed and adhered to, whereas, with a tidal service, passengers have to leave London and Paris at different hours,

and sometimes to arrive inconveniently late. No doubt change of hour is essential; but it is not alone because the service is tidal that passengers have occasionally and necessarily to arrive late, but partly because of the length of time occupied in the journey; and therefore if, as it will hereafter be shown it is, it were practicable to reduce the time from London to Paris from 9½ hours to from 8½ to 8 hours, whilst the time for starting might not be altered, the latest time for arriving, and that only for a few days per month, would be about 10.30 p.m. There is something also in the fact that even assuming that an hour might be fixed which might prove most convenient for the majority of travellers, any one time would not necessarily be desirable for all. For example, to leave early in the morning might be most convenient for a business man, but it might not suit a delicate person or an invalid; and it is an advantage of the tidal system, that a choice of several different hours is offered. As, however, so much has been said in commendation of fixity of service, especially as regards passenger traffic, let it be assumed that it would possess advantages, and let us proceed to consider what practical objections exist to the introduction of such a system. To go no further, it will be sufficient to advert to the want of the depth of water in the existing harbours, which precludes the possibility of a vessel sailing at or near a fixed hour. Hence the advocates of such a service state that, before their views can be carried out, well-sheltered harbours, with deep water, must be provided on both coasts, and thus a fixed service would involve great cost. What is the value of fixity of service? Is it worth, and would it at present compensate for, an enormous additional expenditure of capital, not to mention augmented annual charges? The author's proposals may be briefly summarised as follows:—To provide for a tidal service between Folkestone and Boulogne, and taking care that the vessels, in size and cost of working, did not exceed the paying capacity of the trade, to quote Captain Tyler's recommendation, by "larger* vessels with less movement in rough weather, more shelter, and better accommodation generally;" and, in order to effect this, to carry out certain improvements in the harbour of Folkestone, leaving the French authorities to do the needful at Boulogne, which will probably only include the works now being executed for increasing the backwater, and the arrangements for the landing and embarkation of passengers at the west side of the harbour. The author has not had an opportunity of minutely examining the harbour of Boulogne, but, judging from general knowledge of the port, his strong impression is that little or nothing more would be necessary.

Before proceeding to describe the vessels recommended as suitable, it is important to draw attention to the fact that storms are the exception, not the rule; and it seems only reasonable, whilst not ignoring the exceptions, that the arrangements made should have regard chiefly to the conditions which constitute the rule. Captain Tyler says, in his report, that Captain Boxer, R.N., calculates that there are out of the 365 days, 29 days of gales and storms with heavy seas; 102 days of good round sea and breezes; 144 days with moderate weather and sea; and 90 days of calm weather. Adding to the 90 days of calm weather 144 days of moderate weather and sea, we have 234 days, or about two-thirds of the whole year, during which it may be affirmed that on board moderately large vessels no inconvenience would be felt from either rolling or pitching, and during an additional 102 days such vessels would have but little motion. There are thus left 29 days of gales and storms during which it may be assumed there would be considerable motion, even in the largest ship. But it should be observed:—1. That gales and storms occur principally during the winter, when the passengers are few, less than one-third of those travelling in summer; and therefore the number of days of bad weather is not a correct index of the number of persons who suffer from it; 2. Numbers of passengers avoid crossing in storms, and wait until they have blown over; 3. Any kind of vessel which could be employed would have motion in storms, and, if very large, there would be corresponding difficulty in handling them in the harbours, whilst the fares, from the small number of passengers crossing in the winter, would not meet the expense of running vessels of extraordinary dimensions, and, even if they possessed superior steadiness, it would not be required in summer.

Having now come to the vessels which it is proposed to employ, the chief requirements would appear to be:—1. That they should be steady, or have as little movement as possible in rough weather; 2. That they should be so large as to provide sufficient shelter, roomy airy cabins, ample promenade space on deck, and every convenience for a large number of passengers; 3. That they should have high speed; 4. That they should have exceptional steering powers, and their machinery be extraordinarily handy, so that in the worst weather they might enter and leave the harbours with safety, be easily swung in narrow and confined spaces, and be able to avoid collision with other vessels in thick weather; 5. That, in addition to ordinary holds, the vessels should be constructed to carry on deck the vans loaded with passengers' luggage, and a number of goods-waggons, sufficient, so far as the more valuable kinds of goods are concerned, to accommodate the trade, and so transfer both luggage and merchandise (excluding very light and bulky articles) from one side to the other without breaking bulks.

Having explained his views as to what gives to a ship stability and steadiness at sea, which he does not consider as being synonymous terms, the author say:—In the case under consideration, what we have to be is to give up soil, and diminish the amount of stability required, and then further to augment the steadiness by every reasonable means. Much light has in recent years been thrown upon this question, and it is held that, *ceteris paribus*, we have a measure of the relative steadiness of vessels, in the position of the centre of gravity in relation to the meta-centre, for it has been found that as these centres approach each other the stiffness decreases, but the steadiness increases, and *vice versâ*. From this it follows that the nearer these centres can be brought the better, if we want a remarkably steady ship; and this may be effected—first, by diminishing the breadth of the vessel; second, by increasing the displacement or draught of water; or third, by raising the weights of or in the vessel. The effect of the opposite conditions is seen in ordinary steam vessels of light draught and high speed, which involves great weights of engines and boilers low down; hence such boats are unsteady and roll violently. Lastly, on this point, as affecting rolling, it has been found advantageous to have the means of winging the weights. In vessels for the channel service it obviously would not do to restrict their breadth, because this would be to diminish the space required for the comfortable accommodation of the passengers. Nor is it apparent at first sight how vessels with increased displacement and draught of water could make use of the existing harbour, or how their weights could be raised; but a brief outline description of the proposed steamers will show how steadiness may be secured in the manner indicated without involving what appears to be the corresponding disadvantages.

The author proposes that the vessels should be about 300ft. in length between perpendiculars, and very little more over all, and about 36ft. in breadth. The ordinary draught of water to be 8ft. 6in. with all weights on board, including passengers and their luggage and a considerable quantity of goods; and the vessels to be so constructed that, by the admission of water ballast when at sea in bad weather, they would be steadied by having their draught increased to 11ft. The vessels to be propelled by two pair of paddle-engines driving one pair of wheels amidships, and the speed to be 17 knots. Having two independent sets of propelling machinery, the vessels would require no masts, sails, or rigging. It is further proposed that there should be three cabins for first-class passengers, viz., a main saloon, a ladies' saloon, and a cabin where refreshments could be obtained, and that there should be an after-cabin for second-class, and a fore-cabin for third-class passengers. The first-class ladies' cabin would consist of a lofty saloon, before the machinery; further aft would be the main saloon, of large dimensions; and in connection with all the cabins there would be lavatories and other conveniences. In addition to the unoccupied main deck fore and aft, and over the machinery, and to the wing passages along each side of the saloon cabins, there would be an extended promenade on the upper deck. It is intended that the vessels should be constructed with double bottoms and double sides, in fact, except at the ends, the construction would be, to a great extent, like a hull within a hull; and, excepting where the steam machinery intervened, there would be a lower deck, all fore and aft, and watertight athwartship bulkheads. The result would be great strength combined with lightness, and, what is very important, security in the event of collision. There are other reasons for adopting the construction described, which need not at present be adverted to; suffice it to say that the vessels would be almost unsinkable, a matter of some moment, considering that their course lies directly across the track of ships passing up and down the Channel. Spaces would be provided into which water ballast could be introduced, and thus the draught increased and the vessel steadied at sea in bad weather; and when nearing port the water could be expelled, and the vessel raised to her light draught again. By simple arrangements, these operations, namely, the admission and expulsion of the water, could each be effected in less than five minutes. Such is a general outline of the dimensions and peculiarities of the proposed vessels. Reverting now to the qualities which the vessels were to possess, it will be found that the first was steadiness in a sea-way. There being no masts or top hamper, and no sail to be carried, it is obvious that, as compared with rigged ships, the stiffness might be diminished with perfect safety.

The author does not ignore the fact that, the wind being favourable, sail steadies a vessel, but he wished to obtain a better result than sail would give; and it should be remembered that the full value of sail (for this purpose) could only be realised with the wind abeam or nearly so. Next, the form of hull might be such as, to a limited extent, to diminish the breadth at the water-line without the displacement below; and by

* See that gentleman's valuable Report to Board of Trade.

admitting water into the compartments prepared for it, the draught would be increased, and the displacement still further augmented. The same operation (the admission of water) could be so arranged as in some degree to regulate the position of the centre of gravity of the vessel in relation to the meta-centre, and cause these to approach each other sufficiently near to produce steadiness combined with perfect safety. Moreover, the proposed arrangement would give the commander unexampled facilities for regulating the trim of his vessel, to suit varying conditions of loading and weather, and so to produce the best results. Without going further into the subject it will be apparent to all, that a large, well-proportioned ship would have less motion in our Channel seas than a small, light vessel, dancing on the surface; and, therefore, that the steamers proposed, being (in displacement) about four times as large as those at present employed, greatly increased steadiness and immunity from sickness on the part of passengers might safely be reckoned upon. The next requirement was, that sufficient shelter and comfortable accommodation should be provided for a large number of passengers. A comparison with the steamers at present employed in the service between Folkestone and Boulogne will illustrate the superiority of the proposed vessels in this respect, for it would be found that the area of the deck and the area of cabin would be double that of the largest of the existing steamers. The next requirement was that the vessels should have high speed. It will be enough to say that power sufficient has been reckoned upon to give a speed of 16 knots per hour, even in rough weather, so that, even in adverse circumstances, the passage could be made in about 95 minutes. The time at present allowed, including crossing the Channel, from starting at Charing-cross till the train leaves Boulogne, is about 5 hours 25 minutes, of which 3 hours and 10 minutes is allowed from the time of leaving Folkestone harbour till the time of leaving Boulogne for Paris. On the return journey, the time from leaving Boulogne till the train leaves Folkestone for London is about 2 hours and 40 minutes. Then, as the proposed vessels would make the passage in 95 minutes, and with the improved arrangements contemplated at Folkestone, and the steamers being berthed close to the train on the west side of the harbour at Boulogne, 30 minutes would be sufficient for embarkation and disembarkation, there would be a saving of from 50 minutes to 1 hour and 20 minutes, thus reducing the journey to and from Paris to about 8½ hours. The fourth requirement was that, as compared with the existing steamers, the new vessels should have superior steering and manœuvring powers. The recent opening of the new basin at Boulogne will no doubt do much to diminish the crowding of the tidal harbour, and the works being carried out are designed to improve the channel and entrance. Similarly the improvements which it is proposed should be effected at Folkestone would remove the existing difficulty to the entrance of vessels and their being swung in the harbour; but, nevertheless, chiefly with reference to Boulogne, it is suggested that the machinery of the proposed new vessels should be so arranged that, even in bad weather, they might be readily as well as safely handled. When the International Communication Bill was before the Committee of the House of Commons, evidence was given, by eminent and experienced men, to prove that the increased size of vessel promoted steadiness in entering a harbour; and having had opportunities of discussing this matter with some gentlemen of experience, the conclusion the author arrived at was that such vessels as those proposed could be safely navigated to and from the port of Boulogne as it exists. Although about 300ft. between perpendiculars, they would only be about 70ft. over all longer than the present steamers, and the increased length would render them less subject to be influenced by a heavy sea, whilst with disconnected paddles, and the starting gear now introduced, by which the engines are handled with such facility and rapidity, the course of the vessels would be more perfectly under control than if dependent upon the rudder alone; but as they could enter and leave the port at high speed, and consequently with good steerage way, the influence of the rudder would also be augmented. Inasmuch as the proposed vessels could make the passage in less time than the steamers at present employed, a foot or more of tide might be saved when arriving on the ebb, and as the existing vessels draw 7ft. 6in. to 8ft., the new steamers might have sufficient water although they drew 8ft. 6in. But, to take the worst view of the matter, let it be assumed that there would arise occasions when the proposed vessels could not safely be taken into Boulogne harbour—what would this amount to? It has already been shown that out of the 365 days in the year, the average number of "days of gales and storms, with heavy seas," is only 29. Let it further be assumed that two-thirds of these gales are from the westward, then the remaining third would not preclude large vessels from entering or leaving, because Boulogne "is sheltered by Cape Grisnez from easterly gales." This would reduce the number to 20, and we arrive at the conclusion that, generally speaking, at a period of the year when the number of passengers is small, there would be a few occasions on which one of the existing packets would be substituted for the large vessel, and, it may be, one or two violent storms when no steamer could cross the Channel. With disconnected wheels the vessels could be swung in harbour in little more than their own length, but, still further to facilitate their being handled, it is suggested that they should be fitted with steam capstans. Under this head it may also be desirable to mention that it is proposed that the saloon cabins should occupy the middle portion of the vessel. This is not unimportant, because a deck-house, for example, placed aft, would, from the action of the wind upon it in bad weather, render a vessel less manageable in entering a harbour. The last requirement was that the vessels should be so constructed that the vans containing the passengers' luggage, and a certain number of waggons with merchandise, should be ferried across the Channel without being unloaded. The vans and waggons could be placed by a crane on the main deck, and secured there in a few minutes, but it is suggested with regard to the former that the bodies only should be shipped, and not the frames, wheels, and axles. They could be so constructed that there would be no difficulty in this. Inasmuch as the weight of luggage and goods carried would vary, it seems to the author that the employment of water ballast would be advantageous, for otherwise the trim of the vessel would seldom be that which was desirable. The Channel service is said not to be remunerative at present, and the question naturally arises, how will matters be improved in this respect by employing larger vessels? There are now (between Folkestone and Boulogne) four services per day, viz., a morning or mid-day express boat from each side, and an evening or night boat from each side. This arrangement is no doubt necessary at present, on account of the smallness of the boats employed; but it does not appear that it would be necessary with larger vessels; and the author thinks it could be shown that one boat per day from each side would be quite sufficient for the traffic. It is proposed that the vessels should be arranged to carry five goods waggons on deck, and, in addition, that they should have hold space for carrying a considerable quantity of merchandise below.

Then as to passengers. At certain seasons they are very numerous, but even during the busiest month, August, it would not be necessary to put on an extra steamer until the traffic had greatly increased; for it will be remembered that it has been shown that the proposed vessels would afford double the accommodation to be found in the largest of the existing steamers, and therefore there should be no doubt of their capacity and fitness to carry, at one trip, as many passengers as the present boats carry at two.

Nor does it appear that the existing double service is more convenient for passengers; for what are the facts? By the night service—the time occupied from London to Paris, and *vice versa*, varies from about 16 to 22 or 23 hours, the majority of the services averaging about 17 hours, and it is not conceivable that any one would subject themselves to the inconveniences of such a tedious journey unless for a weighty reason. This reason is doubtless to be found in the reduced charge; but if the fares be less, the profit to the carriers must be diminished, and therefore it is not unreasonable to hold that the passenger traffic by the night boats does not pay. But is it not advantageous to the poorer class? No doubt it is, and if these were very numerous at any period it might be desirable to run one of the existing small boats for their accommodation. At other times, a considerable number of third-class passengers might be carried by the express steamers at a slightly increased fare, compensation for which would be found in the saving of time and diminished cost of refreshment for the journey. Assuming that there would always be sufficient accommodation in the mail steamers for the higher classes who prefer, or are compelled to adopt, night travelling, the author concludes that if the proposed vessels had only to make one passage for two of the existing steamers, it would follow that a great economy in working expenses would ensue, more than sufficient. one would think, to convert the alleged present loss into a considerable profit. It is necessary to have special regard to the protection of the passengers from inclement weather when embarking or landing. This can be readily effected at Boulogne. In the case of Folkestone, the steamers are at times unable to enter the harbour; on such occasions the passengers are compelled to walk to or from the station to near the end of the western pier, exposed to rain and wind, but it is proposed that the embarkation and landing should always take place inside the improved harbour, and directly from the carriages, which would run alongside the steamers, so that the passengers would not at any time be exposed to the weather. The new steamships would, of course, involve additional outlay; but considering that one or two of the present vessels being retained, only two would be required, and that after they were built, the majority of the vessels composing the existing fleet might be disposed of, and that, being fast handy boats, they should realise good prices, it does not appear that a very serious addition would require to be made to the capital invested in shipping. It will be seen that, according to the author's view, it would be better to postpone the establishment of a service at fixed hours until the traffic increased

sufficiently to pay for it. There is nothing startling in the present proposal. It may be said to consist chiefly in a somewhat novel combination of well-tried means to effect a specific resnlt; for, to refer to one prominent feature of the plan, viz., the occasional use of watcr ballast, nnmerous vessels are daily at work which have their dranght thus increased at pleasure, so as to bring them into good sailing trim. The peculiarity of the case under consideration is, the application of this system to secure the comfort of passengers at sea, and at the same time to overcome the difficnlty arising from the deficiency of depth of water in the harbours.

Before concluding, one or two points remain to be noticed. It is obvious that such a system wonld not be applicable for long voyages; that when in rough weather the vessel was pnt down in the water to steady her, in order to maintain the same speed additional power wonld have to be developed by the engines, and thus the consumption of fnel would be augmented. On examination, however, it will be found that the increased working charge for so short a distance is not worth consideration. Dnring fine weather of course the vessel would be steady at her light draught, and therefore it would only be occasionally that she would be immersed to her deep line. There wonld be a snbstantial increase in the first cost of machinery, but, on the other hand, the engines could be worked more expansively, and therefore economically, when the vessel was at light draught. It may occur to some that the varying immersion of the paddle wheels wonld be a difficulty, but it should be borne in mind that the diminished immersion of the floats at light draught would not be inconsistent with the decrease in power reqnired to drive the vessel in that condition.

One word more. The quantity of water to be admitted and expelled for the pnrpose of bringing down the vessel from light to deep draught would necessarily be considerable; bnt it has been ascertained that four centrifugal pumps, and those not of extravagant dimensions, would suffice to effect the expnlsion of the whole in less than five minutes.

REMARKS ON THE PRESENT AND PAST CONSTRUCTION OF THE NAVY.

By Sir William Fairbairn, Bart.

As one of the pioneers of iron shipbnilding, I have ventnred to approach the above subject, but not withont hesitation as to my fitness for such a task. It properly belongs to the Admiralty and professional officers of Her Majesty's navy more than to a civilian. Considering, however, that I have been largely engaged with investigations connected with these important constructions, I may perhaps be excnsed if, in these days of transition, I offer a few remarks on the general character of the ships of the British navy, and the adaptation of the varions forms of vessels to meet the reqnirements of a general and special service.

On the quality of the material, and its adaptation to the different parts of naval construction, I am more at home than I could possibly be in my attempts to advise on the magnitnde, form, and other conditions of a class of vessels of redneed dimensions, intended to meet not only special cases, but at all times to be available for general service either in or out of the fleet. Vessels of this class, with light draught of water, appear, to be essential to the efficiency of the navy; and I venture to question whether these conditions have been carefnlly considered during the numerous experimental researches which have taken place during the last ten years.

The craving appetite for progress in this age of change, has overrun every other consideration but that of large guns and large ships. Large snms have been expended for increasing the power of our guns, and enlarging the size of our ships, which have been overlaid with a thickness of iron armour plating causing them to roll and plunge when they should be active and buoyant.*

To render vessels of this class invulnerable, armonr plates of enormous thickness have been used to cover the sides, from six to seven feet below the water-line to the height of the bulwarks of the upper deck; and these again have rendered the ship nnwieldly in her movements, and deprived her of that celerity of motion which is necessary for either attack or defence.

No doubt vessels of this ponderous class, armed with large guns, are formidable in action, either on the tnrret or broadside system; but the question arises whether a lighter or smaller class of vessels might not be introduced, equally safe and much more hardy than such as the *Minotaur*, *Achilles*, and *Warrior* to which I allude.

I am not adverse to a limited number of ships of 6,000 tons bnrden; but I apprehend that vessels such as the *Bellerophon*, with the same size of guns and properly armour-plated, would be nearly as effective as the larger description of vessels. There is, however, another class of vessels to which I wonld venture to refer, and these are what I would call an intermediate class between the gun-boat and the *Bellerophon*, or from 2,000 to 3.000 tons burthen. These, if well armed with large guns and powerful engines, would, in my opinion, be fit for any service, either in the open sea or the estuary of rivers or harbours which it would be dangerous for larger ships to navigate.

I have been led to these considerations from the circnmstance that the recent Franco-German war may at some fnture time call into existence a class of vessels which, to all appearance, may be shortly wanted. The almost total inaction of the Freuch fleet during the Prussian invasion was evident to every observer, and it would not have escaped the notice of the government that nothing was done. And why this inaction? It must have arisen either from want of foresight on the part of the French Admiralty, or the want of a class of ships of light draught of water, calculated to navigate the waters of the Baltic and the shallows of the North Sea.

During the Crimean war, when Admiral Napier took the command of the Baltic fleet, it was found that our three-decker and large frigates were of little or no use; and in place of a class of vessels capable of reaching the enemy's works, we had to look helplessly ou, without the power of firing a shot. It is true we commenced building gun-boats, which never came into action, and have never been heard of since.

Nothing can be more proper than the present re-organisation of the army; bnt what appears of even greater importance is the re-construction of the navy, on which the defence and safety of this country chiefly depends. It cannot have escaped the attention of the government that the unity and greatly extended power of the new German empire is not withont danger. Its present grasping ambition is not confined to an army of 1,000,000 soldiers and a few small frigates. It appears quite the reverse, as the authorities of Berlin are doubtless alive to every contingency, and are not likely to stop for want of ships when such a wide field of action is open before them. The construction of a large and powerful fleet is sure to be the result, and that united with Russia, and probably America combined, may at no distant period dispute with this country the sovereignty of the seas. We may not have any immediate apprehension of snch an occnrrence; but who are to set limits to German conquests, now that they feel their power and the desire to exercise it when it suits their interests to do so. Donbtless, we have a powerful fleet of iron-clads; but their appears to be a want of ships calcnlated to meet Prussia and Russia combined, in the critical navigation of the shallows of the Baltic, the harbours of the North, and other fortified places of the Black Sea. We conld do little or no damage to either empire with our present class of large vessels; and in order to be prepared for any exigency, a suitable class of vessels, adapted for that and similar services, should not, in my opinion, be lost sight of.

In my work on iron shipbuilding, I endeavoured to point out the advantages of a class of vessels of limited capacity, varying from 2,000 to 2,500 tons burden, which, armed with 400 or 500-pounder guns, and a limited draught of water, would, according to my views, be equal to any service, either in the shallows of the Baltic or the open sea. There may be objections to this descriptions of vessels; but, as far as I can jndge, it appears to meet the requirements of the service in the navigation of inland seas, and, what is of equal importance, would be equally efficient for general service with the fleet.

Referring to these statements, I find in a letter I addressed to the Lords of the Admiralty, dated December, 1864, it is recommended:—

"1. That strong, well-built iron vessels, varying from 3,500 to 4,000 tons burthen, carrying from four to six 350 or 400-pounder guns, having fine lines aud great speed, appear to be the class of vessels which wonld form an important addition to our naval force.

"2. That such vessels be protected, in the line of the neutral axis, by a belt of iron armour plating, varying from 3 to 5ft. above and below the water-line, according to size, all round the ship.

"3. That in cases where the battery is broadside and at midships, the armour plating to be carried up to a sufficieut height on both sides to protect the guns, as shown in the case of the *Penelope*."

This plan of construction was suggested to the Admiralty for the purpose of increasing the thickness of the armour plates, for the protection of the ship below the water-line, aud iu front of the guns on each side where danger was immiuent.

In these recommendations the cellular system, lougitudinal kelsons, &c., were strongly recommended, and the Controllers of the Navy (Sir Spencer Robinson and Mr. Reed) were not slow to avail themselves of them; and hence followed the *Penelope* and the *Bellerophon*, two of the strongest built vessels in her Majesty's Navy.

I have ventured on these observations to show what may yet be

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* There are, however, exceptions to this, as I am informed that the *Bellerophon*, *Hercules*, and *Monarch*, which carry the heaviest guns and thickest armour plates of any ships afloat, are much smaller, steadier, and handier ships than the *Warrior*, *Achilles*, and *Minotaur*.

required to render the navy more efficient, particularly by the introduction of a class of vessels of medium dimensions, light draught of water, and such as are suitable to navigate the Baltic Seas, and reach the innermost recesses of the defensive works of hostile nations.*

ON THE EFFICIENCY OF JET PROPELLERS.

By CAVALIERE B. BRIN.,
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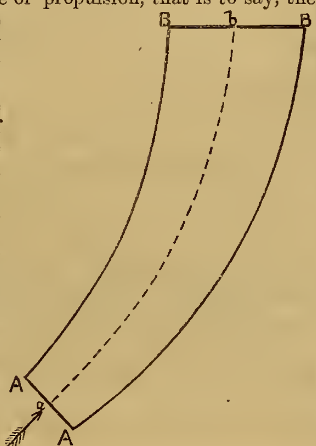
1. Among the various plans for the propulsion of ships which have been proposed or tried, those in which the propelling force is produced by the reaction of one or more jets of water form a special category by themselves. Ruthven's hydraulic propeller, applied first to the *Nautilus* and afterwards to the *Waterwitch*, belongs to this class. The results obtained with it, so far as the amount of useful effect is concerned, were much more satisfactory in the latter vessel than in the former, but were, nevertheless, very inferior to those given by the screw or paddle-wheel. Hydraulic propellers, in certain respects, offer some advantages, and might, under certain given circumstances, be preferred to any other. It has, consequently, seemed to me that it might not be altogether useless to investigate the theory of these propellers, with a view to ascertain if the low amount of useful effect obtained ought to be altogether attributed to the inherent defects of the system, or if it might not be remedied by the adoption of suitable arrangements.

2. In hydraulic propellers, the force of propulsion, that is to say, the thrust necessary to cause the ship to advance, is obtained, as I have already remarked, by the reaction of one or more horizontal jets of water, in a fore and aft direction; in other words, the propelling force is due to the action of a mass of water in motion upon the bounding surfaces of the vessel in which it moves.



Let A A, B B be a receptacle in which a mass of liquid is in motion, and let A A be the inlet section of the liquid and B B that of its exit. Let it be supposed, too, that the arrangements are such that we may assume all the small streams of water to have velocities which are equal and parallel both at their entrance and exit, and normal to the sections A A and B B; also that the motion has become uniform.

Let Ω_0 be the area of the section A A.
Ω_1 that of B B.
V_0 the velocity of the liquid at A A.
V_1 its velocity at B B.
P_0 P_1 the pressures on the extreme sections of the liquid at A A and B B.
α_0, β_0, γ_0, the angles which a normal to the section A A would make with the three orthogonal axes, x, y, z, the last being the vertical one.
α_1, β_1, γ_1 corresponding angles for the section B B.
X, the force impressed on the containing vessel in a horizontal direction and parallel to x.
Y, the corresponding force impressed in a direction parallel to y.
Z, the vertical force impressed on the vessel—that is, in a direction parallel to z.
π, the weight of the liquid contained in the receptacle A A, B B.
Q, the weight of a unit of volume of this liquid.
And g, the velocity impressed by gravity on heavy bodies in a unit of time.

By hydrodynamics, we have for the values of X, Y, Z:—

$$(1.)\ X = -\frac{Q\,\Omega_0^2\,V_0^2}{g}\left(\frac{\cos.\ \alpha_1}{\Omega_1} - \frac{\cos.\ \alpha_0}{\Omega_0}\right)$$

$$(2.)\ Y = -\frac{Q\,\Omega_0^2\,V_0^2}{g}\left(\frac{\cos.\ \beta_1}{\Omega_1} - \frac{\cos.\ \beta_0}{\beta_0}\right)$$

$$(3.)\ Z = -\frac{Q\,\Omega_0^2\,V_0^2}{g}\left(\frac{\cos.\ V_1}{\Omega_1} - \frac{\cos.\ V_0}{\Omega_0}\right)$$

* Since the above was written, I have noticed in the Parliamentary Debates on the Navy Estimates that Mr. Greaves, M.P. for Liverpool, has suggested the construction of a number of gun-boats for harbour defence,—a class of vessels highly valuable for such a service. These do not, however, interfere with an intermediate class, adapted, as I propose they should be, for general service.

If the vessel, A A, B B, have a rectilinear and uniform motion, and this is the case of the propellers of ships, the values of X, Y and Z remain constant.

3. If the inlet section of the vessel, A A, be immersed in the liquid, P_0, is the pressure of the exterior liquid on the plane, A A? Now, as it is required to find the force impressed on the vessel in directions parallel to the three axes, x, y, and z, we may observe that the pressures exerted by the liquid on the exterior immersed portion of the vessel are zero in a horizontal direction, and that no account must therefore be taken of the components P_0 cos. α_0 and P_0 cos. β_0 in the values of X and Y, given by the equations (1) and (2).

With regard to the pressure P_1 on the section B B, this cannot be exerted without causing an equal and directly opposite pressure, either on the sides of the vessel or on the fastenings (in our case on the ship) to which it is fixed. Suppose, for instance, that this pressure is caused by a plunger, the rod of which is merely a prolongation of the piston-rod of a steam cylinder, then on the end of this cylinder there will be produced a pressure, P_1, equal and directly opposite to the pressure P_1, exerted on the section B B of the liquid. Thus, the pressure, P, will have no influence upon the horizontal thrusts exerted upon the system to which the vessel is fixed. Therefore, so far as concerns the horizontal thrusts produced by a mass of liquid in motion on the sides of a containing vessel, considered as propelling forces of the material system, of which this containing vessel forms a part, their value will be expressed by—

$$(4.)\ X = -\frac{Q\,\Omega_0^2\,V_0^2}{g}\left(\frac{\cos.\ \alpha_1}{\Omega_1} - \frac{\cos.\ \alpha_0}{\Omega_0}\right)$$

$$(5.)\ Y = -\frac{Q\,\Omega_0^2\,V_0^2}{g}\left(\frac{\cos.\ \beta_1}{\Omega_1} - \frac{\cos.\ \beta_0}{\Omega_0}\right)$$

4. This premised, let us consider an hydraulic propeller of the kind proposed by Mr. Ruthven. In this system, an hydraulic wheel or turbine, with its axis vertical, sucks in water from the sea through holes in the bottom of the ship, and this water is discharged through two horizontal pipes fixed on each side of the ship at the height of the load water-line. The openings in the bottom are so arranged that the water enters the ship from forward to aft, and in a horizontal direction.

We have thus a mass of water in motion in a vessel fixed in the ship, and the pressure, parallel to the direction of motion of the ship, sustained by the bounding surfaces of this vessel, will be the thrust that caused the propulsion.

If we take for the axis of x a horizontal line parallel to the middle line plane of the ship, and if we take for the positive direction that from the origin of co-ordinates to the bow of the ship the amount of this thrust will be given by equation (4), in which Ω_0 and Ω_1 will be the areas of the orifices of supply and discharge, and V_0 and V_1 the velocities of the water as it passes these orifices, we shall have in this case—

$$\alpha_0 = 180^0,\ \cos.\ \alpha_0 = -1;\ \alpha_1 = 180^0,\ \cos.\ \alpha_1 = -1.$$

We shall therefore have—

$$(6.)\ X_1 = \frac{Q\,\Omega_0^2\,V_0^2}{g}\left(\frac{1}{\Omega_1} - \frac{1}{\Omega_0}\right)$$

And as the volume of water which enters the ship must be equal to that which leaves it, we have—

$$\Omega_1 V_1 = \Omega_0 V_0 \text{ and}$$

$$(7.)\ X_1 = \frac{Q\,\Omega_0\,V_0}{g}(V_1 - V_0)$$

Calling M the unit of water discharged during a unit of time, we have—

$$(8.)\ X_1 = \frac{Q\,M}{g}(V_1 - V_0)$$

Let us call U the speed of the ship. The outside water is at rest, and on entering the ship is met by the water at the inlet section with a relative velocity of $U - V_0$.

At the inlet section, besides the pressure due to the hydrostatic head at this depth, there is a further pressure corresponding to that necessary to impress in a unit of time a velocity $U - V_0$ on a mass $\frac{Q\,M}{g}$. This pressure can be expressed by $\frac{Q\,M}{g}(U - V_0)$; it is horizontal, and its direction is from forward to aft.

The final thrust sustained by the ship, and generated by the volume of water, M, which enters it in a unit of time and leaves it by the dis-

charge pipes, that is to say, the force of propulsion, F, will therefore have for value:—

$$F = \frac{A\ M}{g} \left\{ V_1 - V_0 - (U - V_0) \right\} \text{ or}$$

$$(9)\ F = \frac{A\ M}{g} (V_1 - U).$$

Calling R the resistance offered by the ship to its progress through the water, we have F = R, and the work necessary to overcome the resistance, or the useful work in a unit of time, will be—

$$(10)\ R\ U = \frac{A\ M}{g} (V_1 - U)\ U.$$

5. Let us now seek to ascertain what will be the amount of work necessary to obtain this propelling force, F, and this useful work, R U.

We will retain the notation of section 4 with the following additions:—

L_m, the work developed during a unit of time to produce the jets of water which serve to propel the ship.

V_a, the absolute velocity with which the water leaves the ship; we shall have $V_a = V_1 - U$.

h, the height of the orifices of discharge above the water section of the ship.

During a unit of time, a mass of outer water, $\frac{Q\ M}{g}$, which was at rest, enters the ship and leaves it with an absolute velocity, V_a, at a height, h, above its original level. There will thus be a *vis viva* acquired of $\frac{Q\ M}{g} V_a^2$, and a work expended of Q M h.

On this mass of water there acts the force of reaction of the sides of the vessel, along the length of which this mass of water moves, a force of reaction whose value, as found above, $\frac{Q\ M}{g} (V_1 - U)\ U$. The work exerted during a unit of time to put this mass of water in motion, that is to say the work of resistance, will therefore be:—

$$Q\ M\ h + \frac{Q\ M}{g} (V_1 - U)\ U.$$

During the same period of time there has been transferred to this mass of water in motion a motive work, L_m.

If we neglect friction, the motive work, conformably with the principle of the conservation of *vis viva* must be equal to the work of resistance $Q\ M\ h + \frac{Q\ M}{g} (V_1 - U)\ U$, *plus* half the *vis viva* acquired, *plus* half the loss of *vis viva* occasioned by the shock given to the water on its entrance into the ship. During a unit of time, in consequence of this shock, a mass of water $\frac{Q\ M}{g}$ changes its velocity suddenly from U to V_0; the velocity lost in this shock is therefore $U - V_0$, and the loss of *vis viva* is $\frac{Q\ M}{g} (U - V_0)^2$. The principle of the conservation of *vis viva* next gives us the following equation:—

$$L_m = Q\ M\ h + \frac{Q\ M}{g} (V_1 - U)\ U + \frac{Q\ M}{g} \frac{V_a^2}{2} + \frac{Q\ M}{g} \frac{(U - V_0)^2}{2}$$

But by equation (9) we know that

$$\frac{Q\ M}{g} (V_1 - U) = F = R$$

We therefore have—

$$(11.)\ L_m = R\ U + Q\ M\ h + \frac{Q\ M}{g} \frac{V_a^2}{2} + \frac{Q\ M}{g} \frac{(U - V_0)}{2}$$

The first term of the second number of this equation represent the work necessary to overcome the resistance of the ship, or the useful work. It therefore follows that the actual work expended in this hydraulic propeller must be equal to the useful work, *plus* the work necessary to raise the amount of water employed to the height of the discharge pipes above the water-line, *plus* one-half of the *vis viva* acquired by the water when it leaves the ship, *plus* one-half of the loss of *vis viva* arising from the shock encountered by the water on its entrance into the ship.

We might, therefore, have written down this equation at once from *a priori* considerations. The first term of the second member of this equation representing, as we have said, the useful work, all the other terms represent losses of work.

It will then be necessary so to arrange matters as to make these terms zero, or else to render them as small as possible.

The term Q M h will be zero when $h = 0$, which shows us that it is of advantage to place the discharge pipes at the load water line or below it.

The term $\frac{Q\ M}{g} \frac{(U - V_0)^2}{2}$ will be zero, when $U = V_0$; while the term $\frac{Q\ M}{g} \frac{V_a^2}{2}$ will be zero, when $V_a = o$; that is, if the water left the ship without any velocity at all. But we must observe that $R = \frac{Q\ M}{g} V_a$, so that it is impossible to make $V_a = 0$, since in this case we should require an infinite amount of water, and inlets and outlets of infinite size. Take $V_a = \alpha\ U$, and suppose that the conditions pointed out above for rendering the other losses of work zero have been satisfied, we shall have—

$$L\ m = R\ U + \frac{Q\ m}{g} \alpha^2 \frac{U^2}{2}$$

and

$$R = \frac{A\ M}{g} \alpha\ U;$$

whence we obtain—

$$L\ m = R\ U \left(1 + \frac{\alpha}{2}\right)$$

and the co-efficient of useful effect of the motive work will be—

$$U_t = \frac{R\ U}{\alpha\ U} = \frac{2}{2 + \alpha}$$

If $\alpha = 1$ (as in the *Waterwitch*) we shall have $U_t = 0{\cdot}66$.

6. If the openings by which the water enters the ship, instead of being arranged as in the *Waterwitch*, were so contrived that the water came into the ship in a direction contained in a plane perpendicular to the middle line plane of the ship, the outside water, in that case, which is at rest when it enters the ship, would receive a shock with the velocity, U, of the ship; it would therefore produce a increase of resistance, of which the value would be $\frac{Q\ M}{g}$ U, and there would be a loss of *vis viva* equal to $\frac{Q\ M}{g} \frac{V^2}{2}$.

The value of the horizontal thrust produced by the water in motion would be given by the equation (4) on making $\alpha_0 = 90°$, cos. $\alpha_0 = 0$; and $\alpha^1 = 180°$, cos. $\alpha_1 = -1$.

We should, therefore, have—

$$X = \frac{Q\ M}{g} V_1$$

This thrust ought to be equal to the resistance of the ship, *plus* the increase of resistance indicated above. We shall then have—

$$\frac{Q\ M}{g} V_1 = R + \frac{Q\ M}{g} U; \text{ whence we get}$$

$$R = \frac{Q\ M}{g} (V_1 - U)$$

$$= \frac{Q\ M}{g} V_a$$

The resisting work overcome, that is to say, the useful work, will be—

$$R\ U = \frac{Q\ M}{g} U\ (V_1 - U)_1$$

$$= \frac{Q\ M}{g} U\ V_a$$

The principle of conservation of *vis viva*, by considerations similar to those set forth in section 5, leads us directly to the following equation—

$$L\ m = R\ U + Q\ M\ h + \frac{Q\ M}{g} \frac{V_a^2}{2} + \frac{Q\ M}{g} \frac{U^2}{2}$$

(To be continued.)

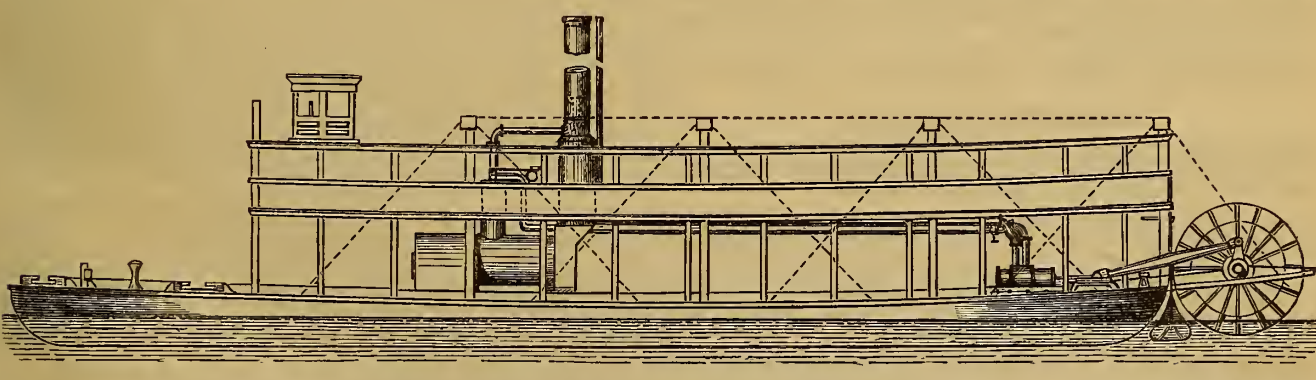
IMPORTANT TRIAL OF STEAM FIRE ENGINES AT PRESTON.

The question as to the relative worth of the steam fire engines of Messrs. Shand and Mason on the one hand, and of Messrs. Merryweather on the other, has at last been decided by the Corporation snb-committee, and there is a very great preponderance of opinion in favour of Messrs. Shand and Mason's. The snb-committee met at the Preston Town hall on the 17th ult., and consisted of Councillor Benson, Chairman; Aldermen John James Myres and Rawcliffe; Councillors Hallmark and Hayhurst. After the preceding meeting the reports of the six practical engineers were printed, and the perusal of them seems to have convinced the sub-committee of the superiority of Messrs. Shand and Mason's machine, for after some discussion ou the varions points adverted to in them, it was decided by a majority of four to one that according to their jndgment the test was strongly in favonr of Messrs. Shand and Mason's, that their engine was superior to Messrs. Merryweather's and that the Corporation be recommended to purchase one for the nse of the borough. The chairman of the committee was at first inclined to the belief that Messrs. Merryweather's was less complicated, but an examination of the working of the two machines, and a consideratiou of the reports of the engineers, induced him not merely to change his view, bnt to become a strong advocate of Messrs. Shand and Mason's. His case in many respects resembles that of the general public, for prior to the trial a notion had been freely propagated that Messrs. Merryweather's was the best, but the practical tests on the bank of the canal satisfactorily demonstrated the superiority of Messrs. Shand and Mason's.

STERN-WHEEL STEAMER FOR SOUTH AMERICA.

A steamboat propelled by means of a paddle wheel fitted to its stern, wears a somewhat antiqnated appearance; nevertheless, for some purposes it possesses merits which can scarcely be attained by any other method of propulsion. Thus, when it is necessary to limit the width of a vessel, side wheels are objectionable, and in cases when the depth of water is very limited, propulsion by means of a screw, becomes inadmissable. Consequently in those cases, where both the width and depth of a river are very small, some other method than these mnst be adopted, in order to work with the greatest advantage. Hence, we find, that in the upper part of many of the rivers in North America, stern-wheel vessels are still nnmerous, being chiefly employed to continne the journey already accomplished by side wheel steamers over the wider portions of the rivers.

The steamboat illustrated by the accompanying engraving, was designed and built by Messrs. Yarrow and Hedley, of the Isle of Dogs, London, for navigating the river Magdalena, South America, being intended for the carriage of passengers and cargo; the latter composed



chiefly of light goods such as tobacco and cotton. The following are some of her dimensions, from which it will be seen that the example of American engineers has to a considerable extent been followed:—Length 167ft.; beam 24ft. 6in.; depth amidships 6ft.; draught of water (loaded) 3ft. The engines are high-pressure, one cylinder being placed on each side of the vessel, driving direct on to the paddle wheel. The diameter of the cylinders is 16in., the length of stroke being 6ft. 4in., being worked by a pressure of 100lbs. per square inch in the boiler.

The boiler it will be seen, is of the locomotive type, and placed at the forward end of the vessel on deck. The paddle wheel is 16ft. 6in. in diameter, 17ft. width of float. The great weights of the machinery being at the ends of the vessel, entail the system of vertical strutts and diagonal ties as shown in dotted lines; rendering the buoyancy of the central portion of the vessel available for carrying the ends. The entire length of vessel below the deck is devoted to the stowage of cargo, and with the exception of bnlkheads is quite unoccnpied.

REVIEWS AND NOTICES OF NEW BOOKS.

Iron and Heat; Beams, Pillars, and Iron Smelting. By James Armour, C.E. London: Lockwood and Co., 7 Stationers' Hall Court.

The object of the first portiou of this work is to instruct workmen in the fundamental principles concerned in the construction of Iron Beams, Bridge Girders, Pillars, and similar mechanical productions. It may be regarded as an axiom, that a workman who, in addition to his mechanical skill, comprehends the reason why he performs certain work, will be less liable to any error on his own part, and also more likely to detect any on the part of the designer, hence the importance of his possessing a certain amount of theoretical knowledge is obvious. As this treatise is designed to enable mechanics, whose instruction has been confined to the three R's, to understand the reason why the work npon which they are set has the particular proportions assigned to it, the information is conveyed in the simplest terms. We consider this part of the treatise will tend towards prevention of errors and promote improvement in workmanship.

The latter part of the work treats upon iron smelting, and in this case also, it consists of a sufficiently popular treatise, to enable the workman to understand the theory of his work without entering upon subjects necessarily beyond his comprehension.

Instructions for the Management of Harvey's Sea Torpedo. London; E. and F. N. Spon, Charing Cross.

Since the outbreak of the American civil war, the torpedo question has been constantly attracting increasing interest; and, if we may suppose that the inaction of the French fleet during the late continental war, was in a great measure owing to the experience then obtained by the Germans upon this question, the importance of the subject is thereby greatly enhanced. The present work, as its title denotes, is devoted to illustrating the manufacture and design of a torpedo, invented by Commander Harvey, R.N., and also to instructions, profusely illustrated by capital lithographs, as to the means to be adopted under varying circumstances, for laying and exploding a torpedo against the side of an enemy's vessel.

It would be impossible withont the excellent illustrations in which the book abounds to explain the full scope of the work, but, we can confidently recommend an attentive perusal of Mr. Harvey's instructions, to all those interested in this comparatively novel subject.

A new Table of Seven-place Logarithms of all numbers from 20,000 *to* 200,000. By Edward Sang, F.R.S.E., &c. London: Charles and Edwin Layton, Fleet-street.

In this work we have the evidence of an immense amount of labour, which can scarcely be called a labour of love by the greatest stretch of imagination. At the same time Mr. Sang undoubtedly deserves the gratitude of scientific men, and all those whose avocation requires them to make elaborate computations, and, we trust he may find satisfaction in the knowledge that he has, through the medium of these tables considerably lightened their labours. The method of notation appears to be very distinct, while it is so ingeniously abbreviated, that each page contains no less than 500 logarithms, thus exhibiting 1,000 numbers at each opening of the book. A concise, but very clear description of the method of computation by logarithms is given at the commencement of the work, by means of which, any person tolerably acquainted with arithmetic may learn to work out in a few minutes a complicated problem that wonld otherwise have possibly occupied as many hours.

[We have received the following:—"The Indian Civil Engineering College," Remarks by a Civil Engineer; "Current Fallacies in Naval Architectnre," by E. Gardiner Fishbourne, C.B., Rear-Admiral R.N., and "Theory of Gunnery," by P. Anstrnther, Major-General late of the, Madras Artillery, (E. and F. N. Spon, 48 Charing Cross), which owing to want of space stand over until our next issue.]

NOTES AND NOVELTIES.

MISCELLANEOUS.

Fire Engines.—We have frequently noticed fire engines tearing through crowded thoroughfares at railroad speed, and wondered why nothing better than the stentorian lungs of the firemen warned passengers and vehicles to give them a clear road. Could we not take a hint from our American cousins, and apply a bell to them, or some other distinctive sound, as a warning, instead of trusting to a noise that is general property, and consequently too frequently unheeded.

The annual report of University College, London, has lately been published, and shows a highly satisfactory condition of affairs. The most important event recorded is the establishment of a new faculty (science), which, says the report, "marks a distinct stage in the development of the college."

The City Gaslight and Coke Company report that since the commencement of the present year nearly one-half of the Beckton station has been called into active and successful operation; and the more fully the large resources of that establishment become developed the greater reason have the directors to be satisfied with their prospect for the future. The manufacture at the Brick-lane and Curtain-road stations is on the eve of suspension, and the directors are already in negotiation for the disposal of a portion of the site of one of those stations, but another year at the least must elapse before the company will begin to reap the full benefit of the great change which it is now undergoing. An unfortunate accident, involving the destruction of one of the large gasholders erected at Beckton, recently occurred. The directors are now in possession of the district and works formerly belonging to the Victoria Docks Gas Company. The directors have introduced into Parliament a bill empowering them to construct a railway to connect the Beckton Works with the Great Eastern Railway, so as to secure an additional outlet for coke and other products, and, at the same time, a means of obtaining supplies of inland coal.

Great exertions are being made in the Channel Islands to render successful the forthcoming exhibition to be held in Jersey in June next. The exhibition will be held in Victoria College and the adjoining. Whilst the products of the Channel Islands will be the most prominent feature, the exhibition will not be confined to them, but will be open to English competitors, of whom many have already signified their intention to be represented. In addition to specimens of the island's industry of all kinds, there will also be a grand display of the cattle for which they are so justly celebrated.

John Mann, a servant in the employment of the Caledonian Railway Company, died at his house, Motherwell, on the morning of the 12th ult. He was the first locomotive engine-driver in Scotland, having come from the North of England to drive the first engine on the old Monkland and Kirkintilloch Railway about thirty-seven years ago. It is further said that he was the oldest driver in the world.

A 200-gallon self-regulating, cleanable, cement-lined tank filter, one of that class recently invented and patented by Captain Crease, Royal Marine Artillery, has for the last three months been on trial in H.M.S. *Minotaur*, the flag-ship of the channel squadron, against one of Atkins' filters of the same capacity. The trial has resulted, very much in favour of Captain Crease's tank filter, which has more than accomplished all that its performances at its official trial in January last promised. This further trial has proved beyond a doubt the possibility of supplying a large ship's company with sufficient pure water for drinking purposes, and has practically demonstrated also how simple a matter it is, in a well-constructed filter, by washing and cleansing the filtering mediums in it, to keep that supply constantly up to the mark. It appears that this tank filter will be generally adopted throughout the service.

NAVAL ENGINEERING.

Mr. Graham of the Goolwa foundry, South Australia, has been making a small pair of marine engines with a boiler. The boiler contains 33 tubes. The engines are of 30 H.P. nominal, working up to 60 H.P. The engines are a copy of a pair fitted on board the *Blanche*, a small local mail steamer.

The fortifications of Cronstadt have been resumed with vigour. The seaward batteries are to be protected with iron shields 10in. in thickness, and are to be mounted with guns of very heavy calibre.

TELEGRAPHIC ENGINEERING.

A great Siberian telegraph line has been now completed. A double wire extends from Sretensk on the Shilka a little way below Nerchensk to Khabarovka, at the junction of the Oussouri with the Amoor. The length of the line is 1,340 miles. The work was commenced August 25, 1870, and was completed November 8, 1870.

A short time ago the cable between Lisbon and Gibraltar was disabled. After considerable labour it was grappled, on February 11th, in 500 fathoms water. It is supposed that, at that depth, the ocean is generally at rest. When brought to the deck of the repair ship, however, there appeared on the cable most evident indications of chafing of very heavy character. It is said that this is the only case of abrasion at such a depth known, and it is important to those who study the geography of the seas, inasmuch as the chafe of the cable appears to indicate the existence of a powerful ocean current, at a depth of 3000ft., along the Spanish or Portuguese coast.

The second telegraph cable which is to connect the new circuits recently completed in the North of Scotland with those in the south, was laid a few weeks ago across the Firth of Forth, between North and South Queensferry. No fewer than eight wires now join London and Edinburgh with Dundee, Perth, Aberdeen, and intermediate districts, and, with the successful accomplishment of the sea section of the route, through traffic may now be maintained by means of all these connecting lines.

STEAMSHIPPING.

The steamship *Hecla* forming one of Messrs. Burns and M'Iver's Liverpool and New York fleet, which arrived in the river some time ago, left again on the 29th March in tow of the Clyde Shipping Company's tugs *Flying Dutchman* and *Flying Squall* for Belfast, where she will be lengthened by Messrs. Harland and Wolfe. The *Hecla* has been dismantled, and her engines, &c., removed.

The Royal Mail steamer *City of New York*, of the Inman line of steamers running between Liverpool and New York, which returned to her station on the 28th March from the Clyde, has just been lengthened 80ft., and completely overhauled, at the works of her builders, Messrs. Tod and M'Gregor, Partick. The length of the *City of New York* is now 388ft. over all, and her gross tonnage 3,500 tons. Her speed has not been impaired by the lengthening, as was shown both on running the lights and by her passage from the Clyde to Liverpool, which was accomplished in sixteen hours.

SHIPBUILDING.

Messrs. Steele and Co., Greenock, have contracted with Messrs. James and Alexander Allan, of Glasgow, for an iron screw-steamer, 360ft. in length, and, we understand, similar to the steamship *Scandinavian*, built last year by Messrs. Steele for the same owners. Her engines are to be supplied by Messrs. Rankin and Blackmore, Eagle Foundry. She is intended for the Glasgow and Montreal trade.

LAUNCHES.

On the 8th ult. Messrs. Robert Steele and Co., Greenock, launched a finely modelled composite cutter yacht, of 100 tons, for Mr. Thos. Houldsworth, Glasgow, late owner of the celebrated cutter *Musquito*. The new yacht, which is expected to sail very fast, was named *Garion* by Miss Ramsey.

A very fine new spar-decked iron screw steamer, of 1,300 tons, built and engined by W. Simons and Co., was launched on the 25th March, from the London Works, Renfrew. She has teak decks and mahogany deck-houses, is classed the highest grade at Lloyd's, and is fitted with compound engines of 180 H.P. nominal. She is named *Isphan*, and is the property of Messrs. Gray, Dawes and Co., London, who intend her for the India trade *via* Suez Canal. Messrs. Simons have in progress a sister steamer for the same owners, to be named *Decan*.

On the 19th ult., Messrs. Blackwood and Gordon launched from their building-yard at Port-Glasgow an iron screw-steamer of fully 1,000 tons burden, for Messrs. Robert Henderson and Son, Belfast, for the Mediterranean trade. On leaving the ways she was named the *Iberia* by Miss Blackwood, daughter of Mr. Ludovic Blackwood, superintendent engineer for the company. Her dimensions are:—Length of keel, 230ft.; breadth of beam, 30ft.; and depth to top of spar deck, 22ft. Immediately after the launch the vessel was towed into the builders' dock alongside of their yard, where she is to be fitted with a pair of compound high and low pressure engines of 120 nominal horse-power, and when finished it is expected that she will realise a good rate of speed. Afterwards a number of ladies and gentlemen assembled in the builders' drawing-room where luncheon was served up, and a number of toasts, including success to the *Iberia* and health of the owners and the builders of the vessel, were given and heartily responded to.

The Irvine Shipbuilding Company have launched a very handsome schooner, named the *Mary Grace*, of Castletown, owned and commanded by Captain C. W. Wilson. Length of keel, 67ft.; breadth of beam, 18ft. 6in.; depth of hold, 8ft. 3in.; burthen, 110 tons. The company intend laying down immediately the keel of a barque of 260 tons register.

On the 22nd ult. Messrs. R. Napier and Sons launched from their shipyard, Govan, a large screw steamer for the Pacific Steam Navigation Company, of Liverpool, and intended for that company's line between Liverpool and South America. The *Garonne*, as this vessel is named, is of similar dimensions to the Pacific Company's recent Liverpool steamers, being about 3,088 tons B.M., with compound engines 550 nominal H.P.; her internal arrangements, state rooms, saloon ,&c., being fitted up and furnished in the handsome style usual in this company's vessels. And the vessel on leaving the ways was christened by Miss Helen Napier, daughter of William Napier, Esq., Eton Place, Hillhead.

On the 22nd ult. Messrs. Caird and Co. launched another large steamer for the Hamburg American Company. The new vessel, which was named the *Vandalia* by Mrs Franzen, wife of the commander, is similar in construction, tonnage, engines, and internal arrangement to the *Germania*, built and engined by the same firm for the Hamburg Company, and which left the river a few days ago. On the same day Messrs. Lyon and Foster launched a schooner of 60 tons register, named the *Lorne*, for Mr. John M'Lachlan, sailmaker. She is intended for the coasting trade. Messrs. Scott and Co. also launched a screw-steamer of 600 tons for Dutch owners. She was named *Etna*. The Greenock Foundry Company are to supply her with compound engines of 90-H.P. The steamer is to be employed in the Baltic trade.

TRIAL TRIPS.

The newly-built double-screw iron gunboats *Bustard* and *Kite*, each of 245 tons, 28-H.P. nominal, and armed with one 18-ton Fraser gun, have made their official steam trials on the ¾-knot course inside the breakwater at Plymouth. On the 12th ult. the *Bustard*, under command of Capt. Charles Fellowes and Staff of the Steam Reserve, which included Mr. Bardin, C.B., Chief Inspector of Machinery Afloat, made six runs over this course at full steam power, with the following result:—Mean speed, 8·105 knots per hour; mean revolutions, port engine, 153·9; starboard, 148·6; mean steam pressure,; 28lb.; mean vacuum, 25¾in.; the vessel's draught was, forward, 5ft. 9in., aft, 6ft. 3in.. the barometer 30. thermometer 54. Wind, S.W.; force, 3; sea moderate On the next day the *Kite*, in charge of the same officers, made six full-power runs over the same course which realized a mean speed of 8·129 knots per hour; mean revolutions, port engine, 151·76; starboard, 146·45; mean steam pressure, 27·3lb.; mean vacuum, 25in., the draught of water being precisely the same as that of the *Bustard* the barometer 30·06, thermometer 55, wind S.W., force 2, sea smooth.

The steamship *Argo*, built and engined by the London and Glasgow Engineering and Iron Shipbuilding Company for the Bristol General Steam Navigation Company, Bristol, proceeded on the 8th ult., on her trial trip with a select company on board. This vessel has been built expressly for the trade betwixt Dublin, Cork, and Bristol, and is fitted up in a most superb style, having accommodation for upwards of sixty first-class passengers. The saloon, which is about 60ft. long by 20ft. broad, for the simplicity and elegance of its fittings has excited the admiration of every one who has seen it. The *Argo* is about 1,250 tons gross register, and has compound engines of the most modern and approved construction. On the run between the Cloch and Cumbrae Lights, she exceeded the speed guaranteed by her builders.

The steamship *Ispahan* of 1,300 tons, built and engined by Messrs. Wm. Simons and Co., Renfrew, for Messrs. Gray, Dawes, and Co., London, proceeded on her trial trip on the 14th ult., loaded with 900 tons deadweight cargo; and although the weather was extremely wet and foggy, ran the lights at a speed which was alike satisfactory to builders and owners. The *Ispahan* has superior accommodation for saloon and second-class passengers, and is now loading at Glasgow for the Red Sea and Persian Gulf ports.

The steamship *Marmion*, intended for the Leith and London trade, went on her trial trip on the 10th ult. under very favourable auspices. She was built by Mr. Lawrie of Whiteinch; and Messrs. James and George Thomson, who were the contractors for the ship, supplied the engines. And her cabin accommodations combine elegance, with every appliance for securing the comfort of passengers. The good ship proceeded to run the measured mile, and afterwards to the Cumbrae Heads, running the Lights back at the rate of 13½ knots an hour—a result which was held to be entirely satisfactory.

RAILWAYS.

A telegram from St. Paul, dated the 13th March, says that the Northern Pacific Railroad Bridge across the Mississippi River, at Brainerd, Minn., was finished that day and the first passenger train, containing officers of the road, passed over the structure. This completes the Northern Pacific 113 miles west from Lake Superior. The grade is finished nearly to Red River, 150 miles further, and at the present rate of progress trains will run to Red River before September next.

The new section of the Rhymney Railway between Cardiff and Caerphilly was formally opened for traffic on the 1st ult.

The Metropolitan District Railway Company are about to erect a large and handsome station at South Kensington in connection with a new junction line now in course of construction, by which they will avoid the station of the Metropolitan Company. The new station will front Pelham-street, and immediately join the existing station of the Metropolitan Company. The contractors Messrs. Waring, Kelk, and Lucas have had a large number of men employed both day and night with the view of having the works completed with all possible speed, in order that they may be ready for opening simultaneously with the completion and opening of the extension from Blackfriars to Cannon-street and the Mansion-house, in the course of the summer. It is only about five weeks since the contractors took possession of the ground, and already the excavations of several portions of the intended line have reached the railway level. The new line runs along and immediately adjacent to the Metropolitan Company's line and station under Pelham-street, and will form a junction with the existing line at the South Kensington Station, a short distance westward of Fulham-road. When completed, the connecting line will give the District Company an unbroken communication between their lines extending from Brompton, westward, and their eastward line in the direction of the City, *via* Sloane-square, Victoria, Westminster, and Blackfriars, and render them altogether independent of the Metropolitan Company's South Kensington station, through which their trains now pass, and for which they have to pay toll. On the completion and opening of the District Company's extension from Blackfriars to the Mansion-house there will be two distinct and competing lines between the western suburban districts and the City—namely, *via* the Metropolitan Company's line from Moorgate-street on the north side, and by the Metropolitan District Company's route from the Mansion-house on the south side.

The Brazilian Government has granted concessions for a line of railway between the Barra Mansa station of the Dom Pedro Segunda Railway and the city of San Paulo, and for the utilisation of coalfields at Araraugua in the province of Santa Catharina.

TRAMWAYS.

The traffic receipts on the North Metropolitan Tramways, four miles in length, amounted for the week ending the 8th ult., for the conveyance of 74,302 passengers, to £678 14s. 4d., being at the rate of £169 13s. 7d. per mile for the past week.

ACCIDENTS.

A large and destructive fire occurred on the 12th ult., on the premises of Messrs. Weson and Gryce's Bolt and Rivet Works, Birmingham. The premises burnt, consisting of a two-storey block of buildings, overlooking the canal, and another block in the rear, were completely gutted, and a large quantity of valuable machinery destroyed. The total damage is estimated at nearly £10,000, which is covered, however, by insurance. The cause of the fire is unknown.

DOCKS, HARBOURS, BRIDGES.

In consequence of the decentralisation of the Black Sea, Sinope is to be improved by the Turkish Government into a first-class naval arsenal and fortress. Batoum will probably be also fortified.

The Albert Bridge, spanning the Clyde at Hutchesontown, is now far advanced towards completion, and is expected to be opened for traffic about the beginning of May.

MINES, METALLURGY, ETC.

Messrs. Hooper and Dodson, brewers, of Nelson, New Zealand, have been experimenting with coal raised at Collingwood. Their verdict has been that the Collingwood coal is better in quality than that received in New Zealand from New South Wales.

The supposed gold mine on Leading Creek, Randolph county, West Virginia, which caused so much excitement several months ago, and which was reported to be worthless, has been pronounced by geologists to be a rich vein of nickel.

The following are some interesting statistics with reference to the newly-discovered coal mines of Berar, in India. The total area of the fields is stated at more than 1,000 square miles, and the coal, so far, has been found at an easy working depth. A late boring at a place called Pisga struck coal at 77ft. from the surface, and pierced 30ft. of coal without passing through the seam. The area of one field, called the Damuda, is stated at 149 miles, and the average thickness of the seam at 40ft., a total amount of coal which Dr. Oldham has estimated at 484,000,000 tons, but which the report calculates to be 4,840,000,000 tons. The estimate, the resident states, would, at the present rate of consumption in India, last for 800 years. Some valuable beds of iron ore also have been found in the Woon district. Probably, the report says, they were worked hundreds of years ago, and abandoned for want of fuel. The minimum thickness of some of the beds is stated at 9ft. of ore, but in one place a bed of 17ft. thick was found. The ore is supposed to contain an average percentage of from 53 to 68·5 of iron.

APPLIED CHEMISTRY.

Dr. E. Schunck, in a paper read before the Manchester Literary and Philosophical Society at the last meeting, described a new acid—anthraflavic acid—which occurs as a yellow colouring matter accompanying artificial alizarine. When crystallised from alcohol and dried, it has the appearance of a dark lemon-yellow silky mass, which under the microscope is seen to consist of slender four-sided prisms. The acid is only slightly soluble in boiling water, and almost insoluble in cold. If pure anthraflavic acid be dissolved in an excess of caustic potash, and the solution be boiled down to dryness, a yellow residue is left, which after being carefully heated, almost to fusion, dissolves in water with a red colour. By the action of caustic potash anthraflavic acid is converted into alizarine, the process being doubtless one of oxidation, though it should be stated that the conversion is never complete, probably because the action, if carried far enough to convert the whole of the acid, leads to the decomposition of the alizarine already formed.

Dr. Letheby has reported upon Dr. Eveleigh's method of producing gas at a low temperature in iron retorts. The peculiarity of the manufacture consists in the distillation of the coal at a low temperature, and the subsequent conversion of the volatile constituents of the tar into permanent gas. This gas is much less offensive than ordinary gas, and it is so rich in hydro-carbons that it cannot be burnt from a standard argand burner with fifteen holes and a 7in. chimney at a larger rate than four cubic feet per hour, giving at this rate the light of 15·7 standard sperm candles.

Letters patent have been obtained by Mr. C. Campbell, of Buffalo, U.S., for an improvement in the manufacture of parchment paper. It consists in passing the paper through a solution of alum and thoroughly drying it previous to its immersion in undiluted acid, thus preventing any undue action of the corrosive principle of the vitriol. The patentee also claims as part of his invention the treatment of the paper with acid during its manufacture, by allowing the web after passing the drying rollers, and with or without previous immersion in the solution of alum, to dip into a tub containing the acid, and then into a vat of water. The paper is afterwards passed through an alkaline bath, being subsequently treated with water to remove the acid. According to the inventor, written and printed paper may undergo this improved process without materially affecting the clearness and distinctness of the letters. Mr. Campbell is thereby enabled to use commercial sulphuric acid in an undiluted state and cold.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	74	0	0	,,	,,	,,
Tough cake and tile do.	72	0	0	,,	,,	,,
Sheathing and sheets do.	74	0	0	75	0	0
Bolts do.	77	0	0	,,	,,	,,
Bottoms do.	79	0	0	,,	,,	,,
Old do.	60	0	0	,,	,,	,,
Burra Burra do.	74	0	0	75	0	0
Wire, per lb.	0	0	$9\frac{3}{4}$	0	0	10
Tubes do.	0	0	$10\frac{1}{2}$	0	0	$10\frac{3}{4}$
BRASS.						
Sheets, per lb.	0	0	$7\frac{3}{4}$	,,	,,	,,
Wire do.	0	0	$7\frac{1}{2}$	,,	,,	,,
Tubes do.	0	0	8	0	0	$10\frac{1}{2}$
Yellow metal sheathing do.	0	0	$7\frac{3}{4}$	0	0	8
Sheets do.	0	0	$6\frac{3}{8}$	,,	,,	,,
SPELTER.						
Foreign on the spot, per ton.	17	15	0	18	0	0
Do. to arrive.	18	0	0	,,	,,	,,
ZINC.						
In sheets, per ton	21	0	0	24	0	0
TIN.						
English blocks, per ton.	129	0	0	,,	,,	,,
Do. bars (in barrels) do.	130	0	0	,,	,,	,,
Do. refined do.	132	0	0	,,	,,	,,
Banca do.	129	10	0	130	0	0
Straits do.	127	0	0	128	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	7	0	1	8	0
IX. do. 1st quality do.	1	14	6	1	16	0
IC. do. 2nd quality do.	1	5	6	1	7	6
IX. do. 2nd quality do.	1	12	6	1	13	6
IC. Coke do.	1	3	0	1	4	0
IX. do. do.	1	9	0	1	10	0
Canada plates, per ton	13	10	0	15	0	0
Do. at works do.	13	10	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	7	6	,,	,,	,,
Do. to arrive do.	7	5	0	7	7	6
Nail rods do.	7	10	0	7	15	0
Do. Stafford in London do.	7	12	6	8	0	0
Bars do. do.	8	0	0	9	2	6
Hoops do. do.	8	15	0	9	0	0
Bars do. at works do.	7	15	0	8	0	0
Hoops do. do.	8	2	6	8	5	0
Sheets, single, do.	9	10	0	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	6
Bars, common, do.	6	10	0	,,	,,	,,
Do. mrch. Tyne or Tees do.	6	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	15	0	7	0	0
Do. Swedish in London do.	,,	,,	,,	,,	,,	,,
To arrive do.	9	17	6	10	0	0
Pig No. 1 in Clyde do.	2	15	0	3	3	6
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. Nos. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	10	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	16	0	0
English spring do.	17	0	0	23	0	0
Quicksilver, per bottle	10	10	0	11	0	0
LEAD.						
English pig, common, per ton	18	5	0	18	10	0
Ditto L.B. do.	18	10	0	,,	,,	,,
Do. W.B. do.	19	10	0	,,	,,	,,
Do. sheet, do.	19	0	0	,,	,,	,,
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	20	10	0	,,	,,	,,
Spanish do.	18	0	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

DATED MARCH 11th, 1871.

648 G. D. Kittoe and P. Brotherhood—Steering vessels
649 W. J. Dickes—Envelopes
650 W. Corbet and W. Griffiths—Fettling
651 W. Inglis and J. F. Spencer—Steam engines
652 M. and M. Tuer and J. Holden—Looms
653 G. R. G. Rowe—Spring clip
654 G. Eskholme—Waterclosets
655 W. Bailey—Trusses
656 H. Gerken—Refining sugar

DATED MARCH 13th, 1871.

657 F. J. Bramwell—Cements
658 T. H. Sykes and J. Stokes—Lessening the emission of smoke
659 G. Hadfield—Preparation of yarns
660 W. and W. Campion—Knitting machinery
661 P. Samain—Firearms
662 H. E. Smith—Ballot voting apparatus
663 J. Dykes—Propulsion of ships
664 A. Annandale—Treating of wood, &c.

DATED MARCH 14th, 1871.

665 J. Mitchell—Looms
666 E. Nillus—Ordnance
667 L. Wright—Potato drill
668 C. Macintosh—Weighing machines
669 G. Swain, Joints or hinges
670 H. L. Corlett—Lifting carriages, &c.
671 A. M. Clark—Handcuffs
672 F. H. Edwards—Prevention of smoke
673 A. Barclay—Coking coal, &c.
674 F. H. Holmes—Fog signals
675 S. Cropper—Printing machines
676 R. Boby—Screen for corn
677 W. B. Robins—Pumps
678 E. Bolton—Oil cakes
679 V. Pendred—Vertical boilers, &c.
680 J. Esson—Locking up type formes

DATED MARCH 15th, 1871.

681 J. K. Broadbent—Gauges
682 M. D. Hollins—Metal plates
683 C. H. Holt—Furnaces
684 H. N. and E. Lee—India-rubber tyres
685 A. Tylor—Valve apparatus
686 A. Murray and J. Cowburn—Looms
687 T. Mortlock and J. Newton—Fencing
688 A. V. Newton—Refining cast iron
689 W. R. Lake—Printers' copying ink
690 A. Robertson—Applying heat, &c.
691 H. Deacon—Bleaching powder
692 E. Feldtmann—Packing
693 G. Allibon and W. Walsh—Constructing telegraph poles

DATED MARCH 16th, 1871.

694 E. A. Crosnier—Shields
695 P. Salmon—Oil gas engines
696 H. A. O. Mackenzie—Organs
697 C. L. Siecinoski—Forges
698 A. Wallis and C. J. Stevens—Elevators
699 J. Millward—Forming elbows, &c.
700 W. Robinson—Regulating the admission of feed water to boilers
701 J. Scharr—Liquid soap
702 C. Mather—Combining gas with air
703 S. J. Hennis—Mineral compounds
704 P. Barnes—Couplings for hose
705 T. H. Blamires and H. Marsden—Carding engines
706 H. Kesterton—Working brakes
707 H. Kesterton—Casting ingots
708 E. Wimshurst—Screw propellers
709 J. and W. Lord and J. Fenton—Spinning cotton waste
710 J. H. Dickson—Obtaining fibres
711 S. E. and T. S. Sarney—Bedsteads

DATED MARCH 17th, 1871.

712 G. Lowry—Hackling machines
713 W. Thompson—Machinery for cutting marble, &c.
714 J. S. Olver—Urinals
715 B. Britten—Artillery
716 T. Seddon—Cleaning cotton
717 W. P. Wilson—Manufacture of gas
718 J. Anderson—Obtaining iron
719 W. B. Gedge—Perambulators
720 C. Wigg—Manufacture of alkali
721 H. A. Bonneville—Carding wool, &c.
722 W. Wheaton and H. Besley—Distributing artificial manures, &c.
723 J. Wright—Manufacture of asphalt
724 J. Paterson—Capsuling bottles
725 W. Tasker—Ricking straw, &c.
726 J. Butler—Indicating
727 W. R. Lake—Driving mechanism

DATED MARCH 18th, 1871.

728 A. F. Osselin—Applying motive power
729 J. R. Wigham—Illuminating
730 T. J. Denne and A Hentschel—Preparation of surfaces for prints
731 J. B. Stoner—Floating lighthouse
732 J. Adams—Machines for crimping
733 J. Holding—Self-acting temples
734 W. Purvis—A quinine biscuit
735 R. Miller and J. Miller—Paper pulp
736 P. Agerup—Steam vessels
737 J. B. Booth—Preparing fibrous materials
738 J. Kendall—Hot-water apparatus
739 C. L. Präger—Railway breaks
740 J. G. Tongue—Textile fabrics
741 J. H. Johnson—Breaking stone

DATED MARCH 20th, 1871.

742 W. Snowden—Cardboards
743 J. F. Haigh—Pickers
744 W. Snowden—Cutter blocks
745 H. Pout—Preserving wood, &c.
746 J. Busch—Regulating the pressure and flow of gas
747 A. M. Clark—Nail-cutting machines
748 W. C. Eyton—Apparatus for consuming gas
749 W. E. Newton—Suspending window sashes
750 W. E. Newton—Roadways, &c.
751 G. Hodgson and J. Broadley—Looms
752 F. N. Gisborne—Signalling
753 H. Deacon—Manufacture of sulphuric acid
754 J. Head—Furnaces for melting, &c.
755 W. R. Lake—Fire-arms

DATED MARCH 21st, 1871.

756 T. G. Rylands—Testing wire
757 C. Hiley—Extracting madder from roots
758 W. H. Mitchel—Retaining lubricating oil in spindle-necks
759 J. Robertson—Repairing knotter, &c.
760 R. Burton and R. W. Burton—Construction of wheels
761 G. Edwards—Pencil cases
762 V. K. Spear—Burnishing heels of boots
763 W. M. Campbell—Letter boxes
764 L. Zimmer and C. A. McEvoy—Floorcloths
765 G. Daws—Signalling
766 E. Russ, T. S. Morris, H. Hammond and E. Hammond—Fire-arms
767 F. Osbourn—Cutting cloth
768 J. Tatham—Breparing wool
769 E. A. Crosnier—Matches

DATED MARCH 22nd, 1871.

770 E. A. Waller—Railway carriages
771 G. T. Yull and J. T. Griffin—Mowing machines
772 J. Tankard and J. Cockcroft—Reeling
773 J. S. Gisborne—Mechanical telegraphs
774 W. Bond and J. Foster—Printing machines
775 G. E. Marchisio and E. Stevens—Purifying isolated oils
776 E. J. C. Welch—Discharging fuses
777 C. Gordon—Fire-arms
778 J. Dewar—Treatment of vegetable substances
779 W. Baines—Working signals, &c.
780 W. Winstanley—Engines and boilers
781 R. Ripley—Compounding alkalis
782 G. Horner—Hackling flax
783 W. H. Balmain—Grinding, &c.
784 J. Flack—Combined blotting pad
785 T. Rowan—Utilising bye-products

DATED MARCH 23rd, 1871.

786 W. C. Collier—Steam drying cylinders
787 J. Pinchbeck—Propelling wheels
788 S. Janicki—Floating dock
789 W. R. Lake—Faucet for bottles
790 T. J. Smith—Extracting juice
791 G. C. Haseler—Lockets
792 J. N. Douglass—Lamps
793 P. Wilson—Bushes for bungholes
794 W. E. Newton—Preparation of fibre
795 J. Swan—Signalling at sea
796 A. V. Newton—Lubricator
797 J. Carver—Bobbin net or twist lace

DATED MARCH 24th, 1871.

798 D. Walker and L. Robinson—Stillages
799 L. E. Broadbent—Shearing
800 G. Marshall—Construction of walls
801 G. J. Cross—Permanent way
802 G. Porter—Ornamenting stone
803 R. F. Fairlie—Locomotive engines
804 R. Dover—Flow of sewage into the Thames, &c.
805 P. Smith and J. F. Donald—Finishing woven fabrics
806 M. Neuhaus—Axle-boxes
807 W. H. Porter—Raising water

DATED MARCH 25th, 1871.

808 G. S. F. Smith—Making screw nuts
809 H. Cherry—Pulley blocks
810 Sir W. Thomson—Clocks
811 J. Hogg—Manufacture of toys
812 W. C. Eyton—Spinning, &c.
813 G. Kent—Smoke consuming apparatus
814 J. K. Pruyn—Sewing machine attachments

DATED MARCH 27th, 1871.

815 J. Brigham and R. Brigham—Mowing machines
816 F. A. Witham and T. Witham—Preparation of cotton
817 A. Innes—Practice register
818 T. G. Webb—Street lamps
819 J. L. Courtice and F. Webb—American organs
820 R. Punshion—Compasses for ships
821 W. R. Lake—Improved garter
822 D. Munro—Furnaces and boilers

DATED MARCH 28th, 1871.

823 P. S. Phillips and T. Hacking—Steam generators
824 H. J. H. King—Motive-power engines
825 W. Ansell—Fire-arms
826 W. R. Lake—Supplying paper
827 W. Wright—Obtaining silver, &c.
828 G. W. Rendel—Self-propelling submerged torpedoes
829 J. Thorton—Carding machinery
830 J. S. Stocks and B. Stocks—Grounding leather
831 R. Thornton and B. Wear—Carding engines
832 T. G. Webb—Windows
833 W. E. Newton—Washing metallic ores

DATED MARCH 29th, 1871.

834 G. Binnie—Making pots
835 H. J. West—Bushes for bung-holes
836 H. B. Fox and W. Evans—Cars, &c.
837 G. N. Sanders—Tools for mining
838 W. R. Lake—Pumping engines
839 A. McFarlane—Wringing machines
840 E. J. C. Welch—Steam engines
841 G. H. Gossip—Bearing reins for horses
842 W. R. Lake—Revolving ovens
843 G. E. Price—Signalling
844 G. N. Sanders—Projectiles for fire-arms
845 A. A. Croll—Ammoniacal liquor
846 T. Hall—Watercloset cisterns
847 B. Solomons—Prismatic compasses
848 T. E. Clarke—Apparatus for heating

DATED MARCH 30th, 1871.

849 W. E. Gedge—Drying sugar
850 M. A. Soul—Escapement for clocks, &c.
851 T. S. Sarney—Securing the ends of rails
852 D. J. Dunlop—Screw propeller engines
853 E. Königs—Treating pyrites
854 E. Lumby—Boilers for heating water
855 F. Hund and R. Hund—Pianofortes
856 W. E. Newton—Decolourising syrups
857 W. E. Newton—Manufacture of gas
858 J. Fordred—Refining paraffine

DATED MARCH 31st, 1871.

859 J. Onions—Basting jacks
860 Sir T. G. A. Parkyns—Bridges, &c.
861 W. C. Westerton—Disinfecting fluid
862 J. Moseley—Wheels for carriages
863 H. W. Dee—Catches of boxes
864 S. W. Thomas—Bicycles
865 G. Nurse—Treating iron
866 J. H. Johnson—Manufacture of iron
867 W. E. Newton—Washing machines
868 F. Wilkinson—Apply tubes, &c.
869 A. V. Newton—Fluid meters

DATED APRIL 1st, 1871.

870 E. Field—Preventing incrustation
871 J. Connolly—Filling bottles
872 F. M. Sims and S. N. Yockney—Signalling
873 C. D. Abel—Purification of glycerine
874 I. W. Boulton—Generating steam
875 M. Reid—Registering
876 J. Rock—Apparatus for desiccating
877 H. E. Towle—Grinding machinery

DATED APRIL 3rd, 1871.

878 M. Christoffers—Knitted machine
879 J. Johnson and W. Jones—Lubricating
880 W. L. Yonge—Improved watch
881 W. Pearson and H. Bradbury—Looms
882 T. Freeman—Fastenings
883 W. Kempe and A. Kempe—Drying machines
884 R. Brydon and J. D. Kendal—Signal indicators
885 J. Smith and A. Watson—Fastenings
886 W. Thomson and A. Macredie—Casting ingots
887 R. Frewer—Apparatus for boring
888 J. Whiting—Hoeing corn
889 D. Crawford—Construction of roads

DATED APRIL 4th, 1871.

890 A. Ott—Separation of tin from iron
891 G. D. Davis—Working rudders
892 A. M. Clark—Sugar-canes mills
893 J. Rowley and J. Humphrey—Syphon measure
894 T. Knowles—Sizing yarn
895 J. H. Riley—Apparatus for folding
896 R. Titley—Mechanism for actuating
897 J. H. Johnson—Packings for piston rods

DATED APRIL 5th, 1871.

898 A. M. Birchall—Preventing explosions
899 A. M. Birchall—Low-water apparatus
900 W. Robson—Slide valves
901 R. Moore—Lubricators
902 I. Smith, B. Smith, H. Smith and C. Bradley—Wool-combing machinery
903 J. Llewellin—Filters
904 F. Claudet—Treating solutions
905 W. Tregay—Apparatus for stamping
906 J. H. Johnson—Motive-power engines
907 W. E. Newton—Pyrometers
908 A. V. Newton—Fluting iron
909 G. Haseltine—Evaporating
910 W. R. Lake—Furnaces

DATED APRIL 6th, 1871.

911 J. B. Wood—Manufacture of fabric
912 W. Nunn—Wheeled covered carriages
913 J. Norman—Sugar-cane mills
914 J. Briggs, R. Willan and D. Lewis—Apparatus for warping
915 T. Thomas—Ventilation of mines
916 C. Harding—Self-raising flour
917 G. Philip—Desks, &c.
918 J. S. Davies—Type-writing machine
919 J. Hughes—Ferules for umbrellas
920 E. T. Hughes—Reeling machinery
921 H. Sprengel—Explosive compounds
922 R. R. Underwood and D. Thomson—Manufacture of iron tubes
923 W. Riddell—Apparatus for disintegrating

DATED APRIL 8th, 1871.

924 C. Wyndham—Bicycles
925 W. E. Newton—Asphalte roads
926 W. Eagles—Measuring machine
927 S. Knowles, J. Ashworth and R. Ashworth—Printed fabrics
928 T. Borlase—Apparatus for dressing
929 E. C. Green—Fire-arms
930 J. Hart—Brooches, &c.
931 F. C. A. von Levetzow—Flower-pots
932 J. W. Woore—Screw-bolts or rivets
933 W. R. Lake—Arranging furnaces
934 T. Atkins—Furnaces for heating water
935 J. Richards, G. Lawrence and J. Lingard—Jewellery
936 T. W. Atlee and G. J. Atlee—Taps
937 D. Mills—Sewing welts

DATED APRIL 10th, 1871.

938 W. H. Bailey—Combing wool
939 W. Hollinshead—Plug valves
940 H. M. Marsden—Mowing machines
941 E. C. Descamps and F. S. Breh—Vault stones
942 H. Stapfer and T. Dean—Filtration
943 W. R. Lake—Utilising exhaust steam
944 R. B. Boyman—Steam ships
945 H. W. D. Dunlop—Disposing words
946 H. L. A. Tottenham—Side weapon
947 S. E. Asquith and F. A. Greenwood—Spinning wool

(MOSQUITO FLEET).

H. M. GUNBOATS

AS BUILT FOR COAST DEFENCES.

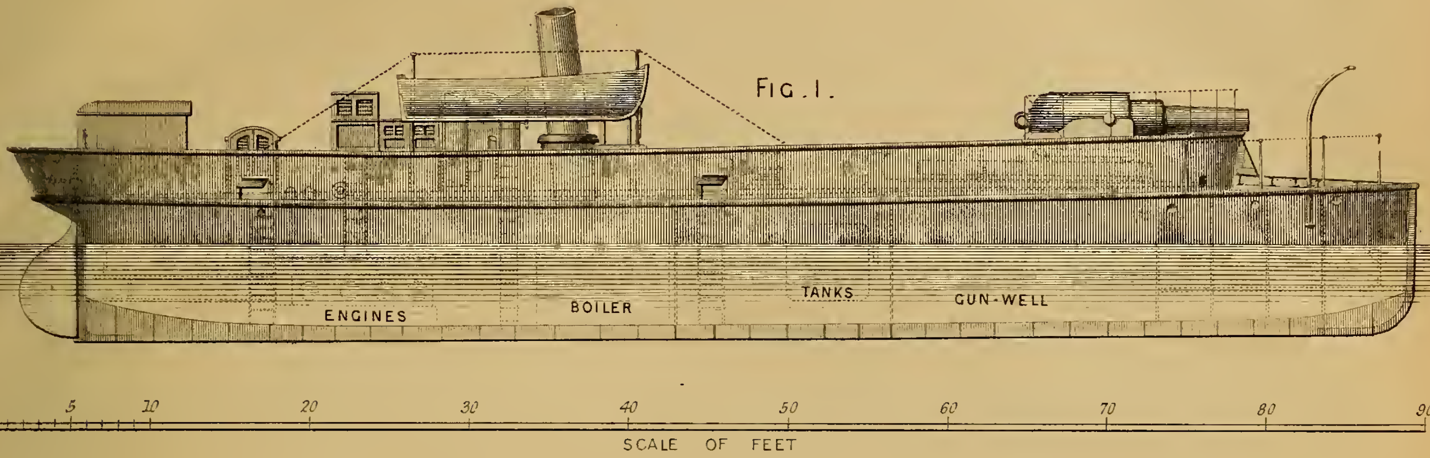


FIG. 1.

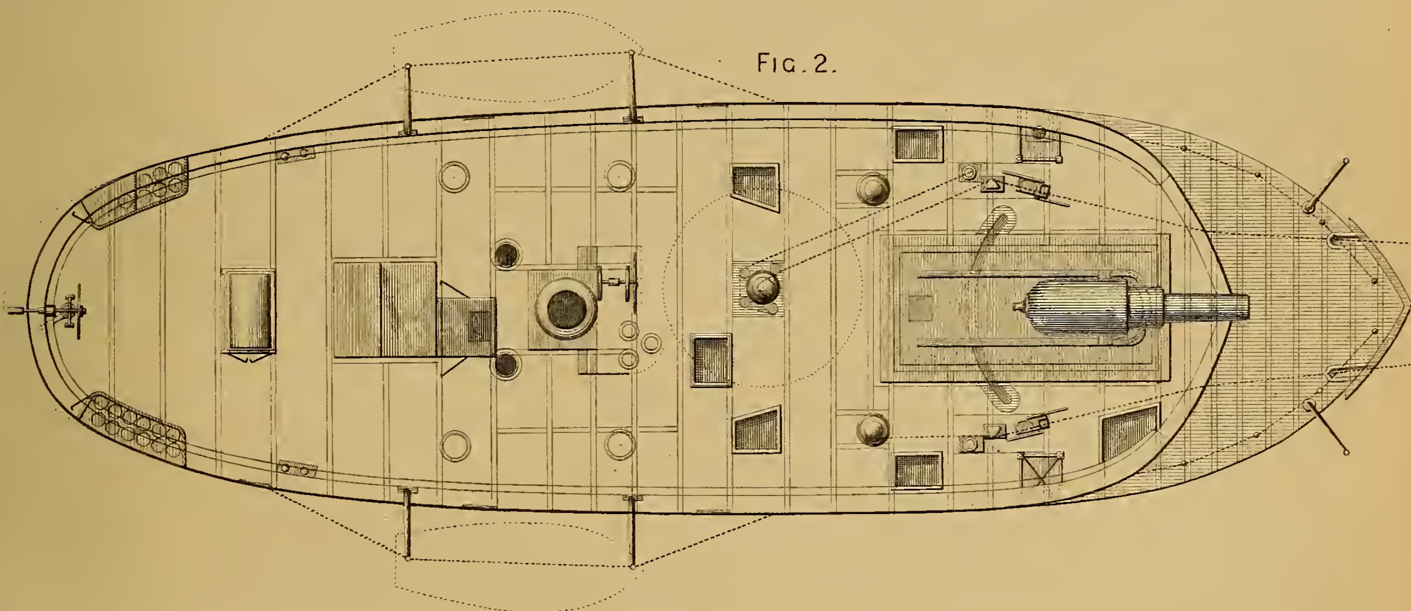


FIG. 2.

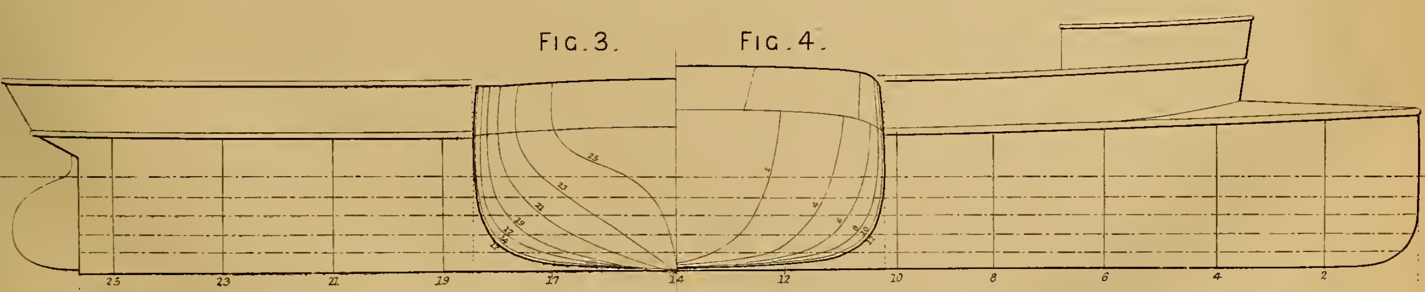


FIG. 3. FIG. 4. FIG. 5.

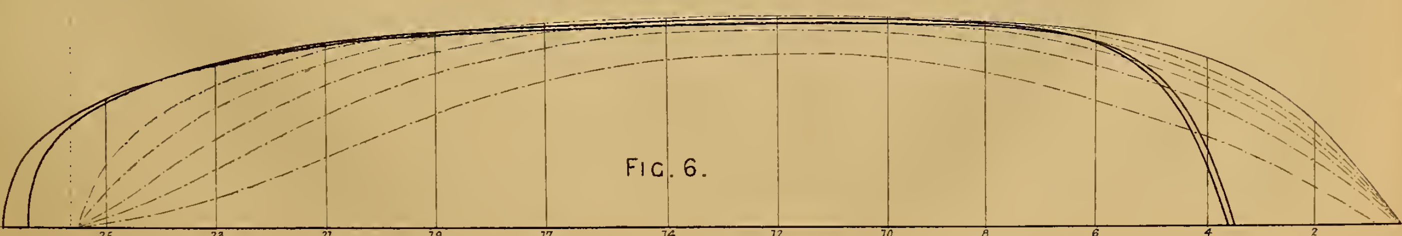


FIG. 6.

THE ARTIZAN.

No. 6.—Vol. V.—Fourth Series.—Vol. XXIX. From the Commencement.

1st JUNE, 1871.

MOSQUITO FLEET.

H.M. Gun Boats as Built for Coast Defences.

(Illustrated by Plate 374.)

In The Artizan of July, 1868, (page 167), an account of a trial trip of what was then considered a novel description of gunboat, was given, together with the leading particnlars of the trial. The size of this new gnnboat (the *Staunch*) was very diminutive, the length being 79ft.; beam 25ft.; draught (mean) 6ft., making a load displacement of only about 150 tons. In spite of this small tonnage, however, the *Staunch* was fitted with a 12½-ton Armstrong gun in her bow, and it was conclnsively proved, that she was perfectly capable of carrying such heavy ordnance. The idea of employing small vessels fitted with one heavy gun, constituting in fact a floating gnn carriage propelled by steam, had, we believe, been freqnently mooted, but it was reserved to Mr. Rendel, of the well-known Elswick firm to carry it into practice. Since the comparatively successful trial of the *Staunch*, it does not appear that the Admiralty took any measures for increasing the nnmber of this class of gunboat, until the absurd war epidemic, which, like the cholera and small pox usually afflicts Great Britain at certain recurring intervals, visited these shores about the middle of last year, and which continued to rage with nnabated violence until an antidote in the shape of 2d. in the pound increased income tax was administered to the unhappy country. The matter was then taken seriously in hand, and a nnmber of gunboats, somewhat similar to the *Staunch*, but, npon an amended design, were ordered forthwith, and we now have the pleasure of giving in Plate 374, the general design, together with the lines of the latest idea of the Admiralty.

It is notorious that the cause of guns *versus* armour plates is even now, not only undecided, but appears to be as far off any satisfactory solution as it was ten years ago. At present the "Woolwich Infant," which we illnstrate in another place, is for the time master of the situation, but it cannot be expeoted that naval architects will rest contented with their defeat. Meanwhile, however, another system of naval architecture, which to a great extent, is independent of the penetrating power of the guns, viz., that illustrated in Plate 374 has been adopted. In this system it appears that the penetrating power of the guns is acknowledged, but their accuracy—not to say their handiness—in a sea way, denied. Hence, in order to insnre as mnch safety as possible from the destructive effects of the modern gun, the plan adopted is, to reduce the size of the target to a minimnm. Thus, on referring to Figs. 1 and 2, (Plate 374), it will be seen, that these new gun boats, in addition to their diminntive size, are designed to go into action "end on," and it is evident that while that position could be maintained, it wonld be exceedingly difficnlt to hit them even at a very moderate distance. We are, of conrse, presuming that the enemy would have very powerful, and conseqnently very few guns on board, as these small vessels are sufficiently powerful to attack with impunity anything, excepting the most modern artillery. Another advantage, inherent to this system, is the distribution of the attacking force into a number of parts, instead of concentrating it in a single bottom. Thus, a snccessful shot from an adversary could only take effect upon one of these small vessels, whereas, in the case of large ironclads, the same shot would, by disabling the larger vessel, effect a proportionately increased destruction. Another great advantage possessed by these small vessels over our large ironclads, consists in their lightness of dranght, whereby, they are enabled either to pursue the enemy, or attack forts, in places where the water is too shallow to admit of the presence of large ships; and also, if necessary, to retire into safety if overmatched.

Since the *Staunch* was built the progress both in the construction of iron-clads and also in guns has been so important that it was deemed necessary to increase the weight of metal in the new gunboats. It has therefore been decided that each should carry an 18-ton gun instead of a 12-ton gun, and in order to do this the dimensions have been proportionately increased. The leading dimensions of these vessels are as follow:—Length, 85ft.; beam, 26ft.; depth, 8ft. 10in.; tonnage, 285 o.m.; armament, one 18-ton rifled muzzle loading gun. The general arrangement is so fnlly shown in Figs. 1 and 2, Plate 374, that little description is needed. It will be seen that, with the exception of somewhat increased dimensions, they are almost precisely similar to the *Staunch*. The gun is so arranged that it can be loaded in the well formed in the vessel, and raised into the position shown in the engraving when ready for firing. For the purpose of manœuvring twin screws are provided, and as in the trial of the *Staunch* it was found that a complete circle could be accomplished in about 1 minnte 50 seconds, with similar machinery, it is evident that this requisite is fnlly provided for.

From the above remarks it will be seen that these vessels are, to a certain extent, well suited for the purposes of coast defence, and would, from the immense power of their guns, prove themselves decidedly awkward antagonists. There are, however, we consider, several grave defects in their design, which go very far towards nullifying their ntility. Thus, on the trial trip of the *Staunch*, which for the present we may fairly take as their representative, a speed of only 7½ knots was obtained, althongh the engines were exerting between five and six times their nominal power. Now, as it is well known that the rate at which a steam vessel travels during a trial trip is never attained afterwards, the normal speed of the *Staunch* may be fairly taken at about 6½ knots per hour. This, we contend, is far too little either for the purposes of attack or defence in actual warfare, and, morever, would in many cases render them perfectly useless for accomplishing the object for which they are principally intended. Thus, in the case of an invasion of these shores, the contemplation of which has lately struck so much terror into the hearts of our legislators, a gunboat of this description would take more than a day and night to travel from Portsmouth to the mouth of the Thames, while from onr next nearest naval station—Plymouth—about donble that time would be necessary.

Another defect scarcely, if at all, of less consequence than want of speed, is their deficiency in coal-carrying power. Thns, taking the case just mentioned, of one of these gunboats having to drag its slow length along from Plymouth to the mouth of the Thames, it wonld be almo s useless when it arrived, throngh shortness of fuel.

Both of these defects, we consider, might be easily overcome by giving the hulls a little less resemblance to a tnb. It has already been noticed, that their length is only 85ft., with a beam of 26ft.; which gives a ratio of about 3¼ to 1 between the length and breadth. With snch proportions, it is of course impossible to attain anything like a respectable amount of speed; in fact, it is a matter of surprise, that, even with the energetic stoking of a trial trip, such a tub could be propelled at the rate

of $7\frac{1}{2}$ knots. If, instead of only $3\frac{1}{4}$ to 1, the proportion between the length and breadth were made 5 to 1, there should be no difficnlty in obtaining a speed of at least 11 knots on the trial trip, and at the same time carrying donble the amount of fuel. It will of course be objected, that to increase the proportion between the length and breadth is to sacrifice handiness, bnt we have yet to learn that a vessel, whose speed is increased more than 50 per cent., and whose fuel carrying capacity is donbled, would be less efficient than the shorter vessel, even if it required half a minute longer to complete a full circle. Althongh, we have allowed half a minnte extra for the longer vessel to make a complete circle, we very much donbt, if, when travelling at full speed, the difference would be so great. As it is well known that most of our merchant screw vessels have a length of from 7 to 9 their beam, it will be seen that onr proposal of 5 to 1 would still leave the gunboats comparatively short and handy, although not so excessively short as to be utterly destructive both to their speed and carrying powers.

Since the above was written, we have had the pleasure of inspecting two of these gun boats just completed by Messrs. J. and G. Rennie, named respectively, the *Arrow* and the *Bonetta*. The exact dimensions of these vessels are :—Length between perpendiculars, 85ft.; extreme breadth, 26ft. $1\frac{5}{8}$in.; tonnage O.M., 244 $\frac{71}{94}$; diameter of cylinders, 16in.; stroke, 1ft. 3in.; number of cylinders, 4. The above named two vessels have been built and fitted out by Messrs. J. and G. Rennie, at Greenwich. Messrs. Rennie also fitted the machinery on board two similar vessels built at Portsmouth, and called the *Comet* and *Blazer*. They also fitted the machinery on board the *Snake* and *Scourge*, building at Chatham. These six vessels are fitted with the same machinery. The *Comet* was tried at Stokes Bay, on the 15th March, giving a mean speed of ship of 8·741 knots, with a mean indicated horse power of 266·4. The *Blazer* was tried at Stokes Bay, on 14th March, giving a mean speed of ship of 8·734 knots, with an indicated horse power of 262·29. From this it will be seen that the new gunboats have attained a greater speed than the *Staunch*; but this is evidently mainly owing to the excellence of Messrs. Rennie's engines. The 18-ton gun is raised and lowered into a well by means of a small high pressure engine, and it was found on actual trial to take about $3\frac{1}{2}$ minntes to raise it from the bottom to the top. The coal consumed on trial was at the rate of about 12 tons per day full speed.

ERECTION OF THE NORTH DONETZ BRIDGE.

The large railway bridge, the iron work for which was last autumn completed at the Old Park Iron Works, under the direction of R. C. Braithwaite, Esq., the manager of the works, has recently been placed *in situ* over the North Donetz River in Russia, being one of the numerous structures execnted during the last few years for the conveyance of traffic on the widely-extended Imperial Railways.

We now purpose giving a brief account of the means adopted in placing the structure in its final position in accordance with arrangements, made by Mr. Braithwaite, which is interesting, inasmuch as the plan was both novel and highly successful; but in the first place, a few general remarks as to the bridge itself will be necessary in order to show the magnitude of the operations undertaken.

The structure itself is 700ft. in length, consisting of four spans carried by four continuous girders, so that from each shore abutment, the railway is carried to the centre pier in the river by two continuous girders, having one intermediate support, as shown in Fig. 1. A represents the land abutment on the south side of the river, and B the central pier and the main girders of the bridge are continuous, from *d* to *e* being also supported by the pier, *c*—*f g* represents a portion of the other half of the bridge, extending from the centre pier B to the north abntment of the strncture. The platform of the bridge is placed on the top of the girders, as there is plenty of headway beneath, for, except in the flood seasons the river occupies no greater space than is comprised in one span; and such are the floods that the water line varies as much as 70ft. The main girders four in number 175ft. long, and 16ft. deep, are of the lattice description, consisting of six series of triangles, having the ties and strnts placed at an angle of 45 degrees to the horizon, altogether forming a stiff though light girder. The total weight of iron work in the whole bridge amounts to 620 tons, including cast and wrought iron and steel, which was constructed and shipped in the short time of four weeks from receipt of drawings. When the bridge was ready to be adjusted in its position, the whole of this weight would not be included, as some slight deduction is to be made of cross bracings, not put in until a later period, so that there would be about 230 tons in each half of the structure. We may now proceed with the actual fixing of the bridge, which from the method adopted, was uninfluenced by the details of its construction. In the first instance, the two halves of the bridge were put together on the banks of the river one half being erected on each side, and so erected that it stood endwise to the river at the point where it was destined to cross, or in other words, the centre line of the bridge lay in the direction of the centre line of the railway for which it was constructed. The position of either half of the work, will however, be rendered more clear by reference to Fig. 2. A B shows the half of the bridge erected on land, in a place made by excavating, so as to bring the top of the girders to the formation level *a a*. The main girders were built up on longitudinal baulks of timber fitted to their bottom flanges, and on the underside of the baulks were rails, which, during part of the movement of the bridge rested on travelling carriages, and during another part, on rollers supported in fixed bearings. From this, it will be seen, the girders were first erected on shore, and snbsequently rolled into position. As the girder is rolled from the position A B, to that shown at D E, being of course properly balanced, the carriages underneath travelling with it fell into a pit C, provided to receive them, and whence they would be subsequently removed. As soon as the extremity E of the girders reached the intermediate pier F, the rails upon the underside of the baulks fitted under the bottom flanges of the girders took their bearings on rollers, carried in fixed pedestals, so the structure moving partly on fixed rollers and partly on movable carriages, completed the distance to the centre pier to meet at G, the end of the other girder G H.

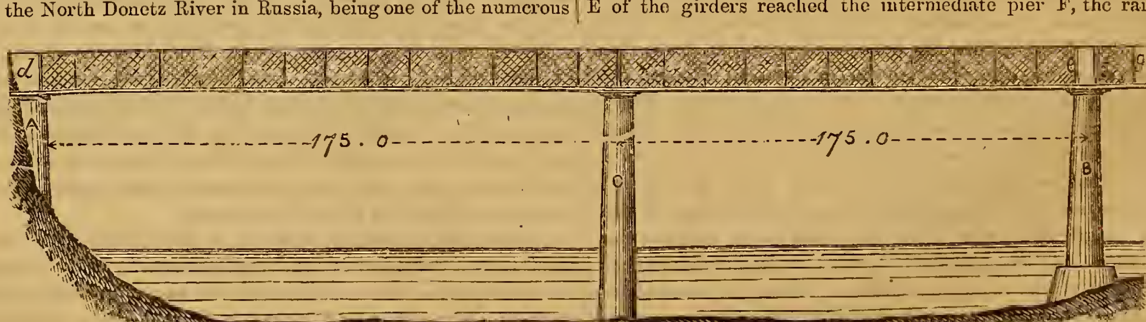


Fig. 1.

After those who were appointed by Mr. Braithwaite had started for Russia,

it occurred to that gentleman, that trouble would bo saved by laying the permanent rails for the movable carriages on an incline towards the river, so that the structure might have a tendency to run by its own gravity to the required position, and although instructions reached too late to apply to the first half of the bridge, this method was used for the second. The incline being 1 in 600. In the first case, the bridge was drawn over by a winch with ease, but in the latter, the work was held back and let down at pleasure. In each instance the girders progressed one span in twelve hours, so that the whole work was placed on its permanent piers in forty-eight hours.

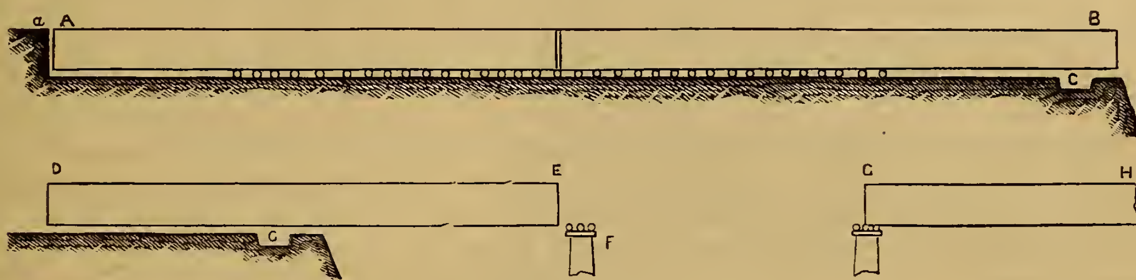


Fig. 2.

To render more clear the details of the process, a cross section of the tramway is shown in Fig. 3. *a a*

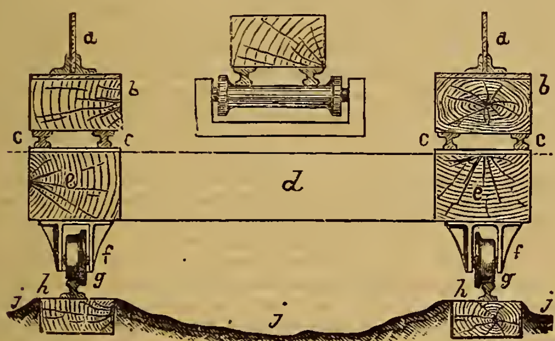


Fig. 3.

show the bottom flanges of the main girders, the baulks of timber fitted to their undersides *c c c c*, the inverted railway bars secured to these timbers *d e e*, the carriage frame having pedestals *f f*, resting on small flanged wheels *g g*, of which there are four to each carriage; *h h* are the fixed rails on longitudinal sleepers *i i*, ballasted as shown at *j j j*. The rollers on fixed pedestals on the piers are shown at *k*, *c c* being the inverted rails bearing upon them. The object of having two rails being to obtain greater steadiness, and to reduce the crushing force upon one point of the rollers.

By using this process in erecting bridges of great size, there are many advantages, and in the first place may be mentioned, the saving effected in doing away with the necessity of erecting a temporary scaffolding across the river, which being of such great height, would have to be necessarily very strong, would be correspondingly costly, and in addition to this, the actual putting together of the bridge on land can be done at less expense than would be incurred were it executed on a scaffolding. The only doubt, therefore, would have been, whether it were safe so to move such large weights, but that it is perfectly safe when all the arrangements are made with due regard to the exigencies of the case and ordinary care used in carrying them out, is now sufficiently proved: so this method is seen to possess many advantages over the former ways of erecting large bridges, and is free from corresponding drawbacks.

GLASGOW AGRICULTURAL SOCIETY'S SHOWS.

(From our Glasgow Correspondent).

The yearly shows of the Glasgow Agricultural Society, took place on the 10th and 11th ult., and has proved quite as successful as on previous occasions, although there were some heavy showers on the second day. The numbers of farmers and visitors attending and money drawn on the first day particularly was most satisfactory to all concerned, and the show of agricultural implements proved fully up to former occasions, and looked especially imposing in neatness and taste of finish as show implements, the local makers especially coming out in this direction, to do credit to the show, and the makers generally with whom we conversed were highly gratified with the interest taken and the orders obtained on the ground. We heard a few of the implement makers from England and distant parts express an opinion that the judges who were all local men, had distributed their favours, especially the medals, to the local makers, more for the polish and finish of their implements, than for any improvement or novelty of construction as is more frequently understood to be the rule, with the honourable exception of the medal awarded to Messrs. Wallace, for an open-eyed or ring wheel at the inside shoe of the finger bar, through which the connecting rod is made to work, although many implement makers express an opinion that owing to the friction of the large eye or ring, would not turn round after being a short time in use from sand and dust getting in. The prize implements looked really well, as also some of those highly recommended: specially noticeable were those of Messrs. Brigham and Co., R. Bickerton and Son, Lillie and Elder, of Berwick-upon-Tweed, as also Mr. Peter Winton's double-furrow plough, though not so highly finished as that of John Gray and Co's., which obtained the medal, a most meritorious example of mechanical construction, especially the parallel acting and moving frame, carrying the outer and forward plough for shifting it to and from the inner main frame and plough, so as to give any width of cut. A notable improvement in seed sowers deserving the medal awarded, it was that of Mr. James Watt, in which the long seed box and spindle in it is divided at the centre, so that the two parts can be swivelled round longitudinally on the main frame or carriage, being convenient for removal through gates, &c. The judges were for implements and machines:—Messrs. John Renwick, Maryhill; William Brock, Barns of Clyde, Yoker; James Myles, Deanside, Renfrew; David Cross, 51 Argyll-street, Glasgow; John Bryce, Abbotsinch; Provost Donald, Johnstone. The parties awarded the medals were:—John Gray and Co., Uddingston, silver medal for double-furrow plough and the general utility of implements; John Wallace and Son, Glasgow, silver medal for their A1 clipper mowing and reaping machines with an improved patented wheel for crossing deep furrows: James Angus, Parkhead near Glasgow, silver medal for his collection of carts; A. Jack and Sons, Maybole, silver medal for their whole collection of implements; James Watt, Biggar, silver medal for a broad-cast sowing machine for grain and grass seeds; John Drummond, Cumnock, bronze medal for a three-horse thrashing machine; David Gordon and Co., Ayr, bronze medal for patent horse gear for churning, &c.; George McCartney and Co., Cumnock, bronze medal for their implements; John Richardson, Carlisle, bronze medal for his farmers; Henry Field and Sons, Glasgow, bronze medal for chairs, &c.; A. and J. Main and Co., Glasgow, bronze medal for galvanised strained wire.

INSTITUTION OF NAVAL ARCHITECTS.

ON A PLAN FOR CONVEYING RAILWAY TRAINS ACROSS THE STRAITS OF DOVER.

By EVAN LEIGH, Esq.

The want of a better communication with France and the Contiuent generally has long been felt, and is growing more urgent every day, from the vast increase of commerce and passenger traffic. The present means of crossing in small steamers, besides being most disagreeable from sea-sickness, being totally inadequate to accommodate the existing demand, to say nothing of the loss of time in loading and unloading the vessels, and other inconveniences, it is, therefore, unnecessary to dilate further upon this point. There cannot be two opinions, that if a better means existed of crossing these dreaded Straits, the passenger traffic would soon become greatly increased, to the great profit of the railway companies on both sides of the Channel, as well as the public convenience; it is, therefore, a matter of the highest importance to railway shareholders, not only of those lines converging on the Straits, bnt indirectly to all parties interested in railways throughout both England, France, and the Continent generally. The present system has been aptly likened to a bandage tied round the neck of commerce, of which England is the head and the Continent the body; a bandage which is daily producing a greater degree of strangulation, and, like a throttled monster, is now making such deperate efforts to free itself, that nothing seems too wild and daring to effect this object, as will be seen from a short review of the various plans proposed.

First comes the plan I am about to exhibit in detail, and which occurred to me in the spring of the year 1861, when I was crossing the Atlantic in the *Great Eastern* steam-ship. The *Great Eastern* showed that if a boat was made long enough, there would be no pitching even in the roughest weather, and to overcome the rolling, my idea then was to build a vessel on pontoons. This plan I showed at the International Exhibition of 1862, and called public attention thereto, by distributing lithographs illustrating the principle, accompanied by a description. Before the opening of the Exhibition, I showed my models in London to the Lords of the Admiralty and other nautical gentleman, but public opinion did not then seem to be ripe for such an undertaking.

When a subject of vast national interest and importance gets propounded, a number of aspirants arise to show various other ways of carrying it out than the plan proposed by the originator; and were it not for the evidence of priority furnished by the much-abused patent-laws, it would be impossible to ascertain amongst the numerous claimants who was the first inventor of anything. Lately, soundings and borings have been taken, with a view to drive a tunnel under the sea at all hazards. How great those hazards will be may be surmised by those who remember the vast expense and failures of the comparatively insignificant affair of the Thames-tunnel, originated by the late Mr. Brunel. Desperate, indeed, must be the uecessity of effecting this communication, for such Utopian ideas to be entertained as are propounded even by men who have the reputation of being practical engineers. How could capital be found for making a tunnel that would probably take twenty years to accomplish, and even if ultimately successful, might be swamped any day? Another scheme, by a French engineer, is to fill up the Channel with islands at easy distances apart, so as to bridge them over by girders. To say nothing of the great length of time and enormous expense of this plau, the unstable foundation, exposed to the rongh sea and currents of the Straits of Dover, renders it quite impracticable. Another plan, similar to the last, is to fix strong piers of iron and concrete, filled up about the base with stones and rubble to a certain height for greater stability, and bridge over from these. This plan is more practicable, but the expense would be enormous, and the time spent in construction considerable. Another, and very ingenious plan, is to tunnel the Channel by means of iron tnbes cased with bricks; but the difficulties and risks to be encountered in this scheme are so obvious that it is very doubtful if capital could be found to make the attempt.

Supposo, however, for argument's sake, that any of the above-named plans could be practically carried out, it is clearly impossiblo that they could be commercially successful. The interest of the money expended, and the expense of keeping the work in repair would be so enormous, that they wonld not have the slightest chance of competing with the large ferry boats that can so easily be made to take the trains over in any weather, or at any state of the tide, as will be seen on reference to my diagrams, which show a goneral plan of steam ferry and a section of same, with harbour; a breakwater, about the same length as tho ferry-boat; at the upper end of the harbonr is a floating landing-stage, to which one end of the bridgo is attached by strong hinges, the other being hinged on the land side. A double line of rails are laid on this bridge to correspond with the np and down rails. The centres of the bridge-hinges are in a line with the top of the rails, so that there will be no gaping of the rails when the tide is out. At half-tide, the rails on the bridge form a straight liue with those on the boat and the rails on laud. To compensate for the slight difference in distance, caused by the arc of the curve made by one end of the bridge moving up and down, the landing-stage, to which it is firmly hinged, will be thrust a little further out in the dock at half-tide, or drawn nearer to the shoro at high and low water. This difference will only be about three inches. By this arrangement, an exact junction is effected with the rails ou deck and those on the bridge, whatever be the state of the tide when the boat comes into harbour, and is seized by the catches which hold it firmly up to the rails. To compensate for any inequality in the draft, caused by the boats sometimes being more heavily laden than at others, the following provision is made, admitting of as great a difference as 1,000 tons, if required. When the bow of the boat comes into the indent of the landing-stage, the rollers run up an incline, depressing the landing-stage while it is being raised itself, until seized by the catches, when the junction with the rails is effected, and is held firmly to the bridge and landing-stage, until again liberated by withdrawing the catches after another train has come on board. As the construction of the boat is the same at both ends, it is not required to be turned round. The bottom of the boat is provided with a keel, not reaching from end to end, but stopped off a sufficient length, so as not to interfere with the landing-stage. A rudder is fixed at each end of the keel.

RUDDERS.—The rudders are connected together, so that one cannot move without the other moving in the opposite direction, thereby effecting an equilibrium more perfect, and, it is submitted, more mechanically correct, than any other plau that can be devised.

PADDLES.—The paddle-wheels are each made of two cylinders constructed of Bessemer steel or wrought-iron plates, the larger one being about 24ft. diameter, aud the smaller one, which is fixed concentric within the other, is about 12ft. diameter; the ends are made up air-tight by boiler-plate, so as to form an angular space, strengthened internally in a suitable manner by ribs of iron or stays. The paddle-shafts are fitted inside by bosses and skeleton snpports, similar to a water-wheel, The floats are (by prefereuce) of wood, bolted to snugs, rivetted to the outer casing. These snugs are made of T iron, and stretch from paddle to paddle, being beut up at each end, and bolted together through the float-boards, which are dished out to drop in flush with the iron snugs. The float-boards are 6in. thick by 15in. deep, and taken off to 2in. thick at the top; they are ouly of sufficient length to stretch half across the paddle-wheel, being set at intervals between each other. As the floats are always working in dense water, it is only necessary to have them abont 12iu. to 15in. deep, and being tapered from 6in. thick at the bottom to 2in. at the top, will have no tendency to lift the back water. The floats will project below the bottom of the vessel about 12in., and the keel about 3ft. The perforations through the bottom of the ship where the paddles work are the length of the diameter of the paddle-wheels, and sufficiently wide to admit of the paddle-wheels (without shafts) to be put in their places from below.

ENGINES.—These are four steam cylinders, of about 40in. diameter and 15ft. stroke, two to each paddle. The engines are on the oscillating principle, and in making 30 strokes per minute, have a piston speed of 900ft. per minute. They are fitted with expansiou valves, to cut off the steam at any part of the stroke, aud have surface condensers.

BOILERS.—Those are on the water-tube, high-pressure principle, proved up to 500 pounds to the iuch, and work at a pressnre of abont 70 ponnds.

COST.—Two of these ferry-boats, with a harbour and bridgo on each side of the Chanuel, can be built complete at a cost not exceeding £1,250,000, which will allow a fair margin for contingencies. Interest of capital, at 5 per cent. per annum, on this sum, seamen and stokers' wages, fuel, &c., wonld not exceed £300 per diem. If each boat made five trips in and out per day (which would be twenty crossings altogether, ten from each side), the expense of each crossiug would not exceed £15.

RESULTS.—Takiug the present estimate of passengers per day at 3s. each, and 100 tons of goods at 3s. per tou, or its equivalent, will leave a profit of 10 per cent. on the capital. Trains would run on tho boat in the same manner as running into a railway station, and be despatched without a moment's delay, regardless of tides or weather, making passage in fifty minutes. Speed, comfort, safety, aud frequency of passage cannot fail to increase tho traffic euormously, far exceeding the above estimate, when a small additional outlay would enable boats to be despatched to Ostend and Boulogne, as well as Calais, from the Dover Ferry Railways debouching on tho coast, would be enriched to a greater extent than the cost of the whole scheme.

In this estimato nothing has been said about the conveyauce of mails, parcels, &c., which are put down at an euormous sum in other estimates.

Comparison.—Supposing a tunnel or bridge were possible, the cost would probably be more than ten times greater, and the expense of keeping in repair and working order equally augmented, affecting the charge for transit of passengers and goods in the same ratio, therefore there can be no doubt whatever as to the superior economy of this system. Then, again, the comparatively short time required to put the ferry-system in operation is favourable, in about the same degree as the cost, not amounting probably to a tenth of the time required for either bridge or tunnel. A tunnel would also command a monopoly of the service, as all railway lines would be compelled to bear upon it, which would be very inconvenient; the same may be said of a bridge; whereas ferries could be established in other parts of the coast, ultimately, besides Dover, which would greatly tend to the public convenience.

ON THE EFFICIENCY OF JET PROPELLERS.

By Cavaliere B. Brin.,
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(*Concluded from page* 116.)

We shall see immediately that we ought to make $h = 0$.

If we take $V_a = \alpha U$, we shall have—

$$L\,m = R\,U + \frac{Q\,M}{g}\,\frac{\alpha^2\,U^2}{2} + \frac{Q\,M}{g}\,\frac{U^2}{2}$$

We have—

$$R = \frac{Q\,M}{g}\,V_a \text{ which gives}$$

$$L\,m = R\,U\left(1 + \frac{\alpha}{2} + \frac{1}{2\alpha}\right)$$ and the co-efficient of useful effect of the motive work will be—

$$Ut = \frac{1}{1 + \frac{\alpha}{2} + \frac{1}{2\alpha}}$$

$$\text{If } \alpha = 1$$
$$Ut = 0{\cdot}50$$

We see, therefore, that this arrangement is less advantageous than the preceding. Such an arrangement was adopted in a steamboat constructed by Cockerill's Company, which was exhibited at the Paris Exhibition of 1867.

7. Let us suppose, now, that the openings in the bottom of the ship are arranged in such a manner that the water enters in a direction horizontal and parallel to the middle line plane, and from aft forward.

In this case, the thrust exerted by the body of water in motion will be given by equation (4) on making $\alpha_0 = 0$, cos. $\alpha_0 = 1$; $\alpha_1 = 180°$, cos. $\alpha_1 = -1$.

We shall then have—

$$(12.)\quad X = \frac{Q\,\Omega_0^2\,V_0^2}{g}\left(\frac{1}{\Omega_1} + \frac{1}{\Omega_0}\right)$$

$$= \frac{Q\,M}{g}\,(V_1 + V_0)$$

This value of X represents the force of propulsion, F, and we shall have—

$$(13.)\quad F = R = \frac{Q\,M}{g}\,(V_1 - V_0)$$

8. With regard to the work required in order to obtain this force of propulsion, it may be determined by considerations similar to those set forth in section 5.

We will use the same rotation as that adopted in the preceding sections.

In a unit of time—

The *vis viva* acquired will be $\frac{Q\,M}{g}\,V_a{}^2$,

The motive work developed, L_m,

The work of resistance due to gravity, $Q\,M\,h$,

The work of resistance due to the reaction of the surface of the channels along which the water moves, $X\,U = \frac{Q\,M}{g}\,(V_1 + V_0)\,U$.

We shall therefore have—

$$(14.)\quad L_m = \frac{Q\,M}{g}\,\frac{V_a^2}{2} + Q\,M\,h + \frac{Q\,M}{g}\,(V_1 + V_0)\,U.$$

$$\text{or as } R = \frac{Q\,M}{g}\,(V_1 + V_0)$$

$$(15.)\quad L_m = R\,U + Q\,M\,h + \frac{Q\,M}{g}\,\frac{V_a^2}{2}.$$

The first term of the second member of this equation represents the useful work; all the others injurious work.

We must therefore make—

$$h = 0$$
$$V_a = 0$$

Having satisfied these conditions, we shall have $L_m = R\,U$, and the co-efficient of useful effect, $U_t = 1$. That is to say, the motive work will equal the work of resistance. This propeller should therefore be theoretically perfect.

9. It is now necessary to determine what conditions must be satisfied by the hydraulic machine which has to set the water in motion and discharge it from the ship, so as to utilise the motive power as perfectly as possible. For this purpose we may employ one of the numerous hydraulic machines for raising water. But as it is required to produce continuous jets, and to avoid intermission as well as to set in motion very considerable bodies of water, there can be no doubt that centrifugal pumps or turbines, constitute in this case the best form of hydraulic machine to employ.

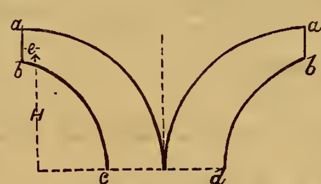
Let us call

T, the moving force transmitted to the shaft of the turbine in a unit of time.

V, the velocity of the extremities of the vanes of the turbine (if u is the angular velocity.)

R, the radius of the turbine.

N, the number of revolutions of the turbine in one minute; so that $V = R\,u = \frac{2\,\pi\,N\,R}{60}$.



H, the height of the centre, e, of the extremities of the vanes above the section, $c\ d$, of the inlet of water into the turbine.

H_1, the height of the orifices of discharge above the point e.

P, the height of the column of water which measures the pressure at the section, $c\ d$, of the inlet of the water into the turbine.

v, the velocity of the water at the section $c\ d$.

For the remainder we will adhere to the notation of the preceding sections.

If we disregard the friction and the losses of work due to throttling, sharp turns, and so forth, the work, T, ought to be equal to that necessary to raise the weight Q M to the height $H + H_1 - P$, *plus* the work corresponding to one-half the *vis viva* $\frac{Q\,M}{g}\,(V_1^2 - v^2)$ acquired by the water, from its entrance into the turbine until it leaves the orifices of discharge, *plus* also the work corresponding to one-half of the losses of *vis viva* that take place in this kind of hydraulic machine, and which are:—

$\frac{Q\,M}{g}\,a^2$, on the entrance of the water into the turbine, where a is the velocity lost in the entering.

$\frac{Q\,M}{g}\,b^2$, on the exit of the water from the turbine, where h is the absolute velocity with which it leaves the turbine.

We shall therefore have—

$$(16.)\quad T = Q\,M\,(H + H_1 - P) + \frac{Q\,M}{g}\,\frac{V_1^2}{2} - \frac{Q\,M}{g}\,\frac{v^2}{2} + \frac{Q\,M}{g}\,\frac{a^2}{2} + \frac{Q\,M}{g}\,\frac{b^2}{2}$$

The loss of *vis viva* $\frac{Q\,M}{g}\,\frac{a^2}{2}$ on the entrance of the water into the turbine, may be almost entirely obviated by making the vanes of a suitable shape; we shall therefore neglect it.

Let us put

$$(17.)\quad H + H_1 - P + \frac{V_1^2}{2g} - \frac{v^2}{2g} = \frac{\mu^2}{2g}$$

$\frac{\mu^2}{2g}$ will represent the column of water which the turbine has to take up, and $Q\,M\,\frac{\mu^2}{2g}$ the useful work in a unit of time.

We shall have

$$(18.)\quad T = Q\,M\,\frac{\mu^2}{2g} + \frac{Q\,M}{g}\,\frac{b^2}{2}$$

The term $\frac{Q\,M}{g}\,\frac{b^2}{2}$ represents a loss of work, we ought, therefore, to diminish this term or the velocity, b, as much as possible.

Let us determine this velocity.

The relative motion of the water in the turbine is determined by the pressures at the inlet section, $c\,d$, and by those at the outlet, $a\,b$, by gravity and by the centrifugal force.

Let v_r be the relative velocity acquired by the water on its exit from the turbine under the action of these forces. The work developed by these forces in a unit of time will be—

1st. That of the pressure at the entrance will be $Q\,P\,\omega\,U$, ω being the area of the section through which the water enters the turbine, and U the relative velocity of the water at this section.

Now we have $\omega\,U = M$, so that the work done by this force will be $Q\,P\,M$.

2nd. That of the pressure upon the orifices of discharge of the water from the vanes of the turbine will be $Q\,P_1\,M$.

3rd. The work done by gravity will be $-\,Q\,M\,H$.

4th. With regard to the work done by the centrifugal force, we know that the work transmitted by this force to a body $\frac{Q\,M}{g}$ which, having a rotatory motion of which the angular velocity is w, starting from rest, moves off from the axis to a distance, R, has for its expression

$$\frac{Q\,M}{g}\,\frac{w^2\,R^2}{2} = \frac{Q\,M}{g}\,\frac{V^2}{2}$$

The principle of the conservation of *vis viva* then leads to the following equation :—

$$Q\,P\,M - Q\,P_1\,M - Q\,M\,H + \frac{Q\,M}{g}\,\frac{V^2}{2} = \frac{Q\,M}{g}\,\frac{v_r^2}{2}$$

whence we have

$$P - P_1 - H + \frac{V^2}{2g} = \frac{v_r^2}{2g}$$

The velocity V_1 of the water at the orifices of discharge will be due to the height $P_1 - H_1$. We shall therefore have $\frac{V_1^2}{2g} = P_1 - H_1$ and $P_1 = \frac{V_1^2}{2g} + H_1$ which gives us $\frac{v_r^2}{2g} = P - \frac{V_1^2}{2g} - H_1 - H + \frac{V^2}{2g}$ that is to say $\frac{v_r^2}{2g} = \frac{V^2}{2g} - \frac{\mu^2}{2g}$

Whence we derive

$$v_r = \sqrt{V^2 - \mu^2}$$

The velocity of the water, v, which it will have when it quits the turbine will be the resultant of V, the velocity of the ends of the vanes, and of the relative velocity v_r of the water tangentially to the ends of the vanes.

Calling e the angle which the tangent to the ends of the vanes makes with the outer circumference of the turbine, we shall have—

$$(19.)\quad b^2 = v_r^{\,2}\sin.^2 e + (V - v_r\cos.\,e)^2.$$

We have seen that it is necessary to endeavour to render v a minimum ; with this object we must make $e = 0$.

We shall then have

$$b^2 = (V - v_r)^2 - (V - \sqrt{V^2 - \mu^2})^2$$

In order to get rid of the velocity v, it would be necessary to have $V = \infty$, whence we see that it is impossible to overcome the loss of momentum $\frac{Q\,M}{g}\,b^2_1$ and that it is an advantage to make the turbine revolve with a great velocity.

If we substitute the value of v^2 found above in the equation, which gives as the expression of the motive work, we shall obtain the following equation :—

$$(20.)\quad T = Q\,M\,\frac{\mu^2}{2g} + Q\,M\,\frac{(V - \sqrt{V^2 - \mu^2})^2}{2g}$$

The term $Q\,M\,\frac{\mu^2}{2g}$ represents, as we have said, the useful work obtained by the turbine, so that the co-efficient of useful effect of the motive work will be—

$$U'_t = \frac{\mu^2}{\mu^2 + (V - \sqrt{V^2 - \mu^2})^2}$$

This co-efficient can only become unity when $V = \infty$.

If we make $V = \mu$, we shall have $U'_t = 0{\cdot}50$.

,, $V = 1{\cdot}25\mu$,, $U'_t = 0{\cdot}80$.

,, $V = 2\mu$,, $U'_t = 0{\cdot}93$.

But practically we cannot make the angle e vanish, that is to say, we cannot arrange the ends of the vanes tangentially to the outer circumference of the turbine, for if we did so, the water which leaves one vane would strike the following.

We ought to make $a = 20°$ as in good centrifugal pumps ; then we shall have—

$$b^2 = v_r^{\,2}\sin.^2 20° + (V - v_r\cos.\,20°)^2$$

In this case, the co-efficient of useful effect will have for value—

$$(21.)\quad U_{t'} = \frac{\mu^2}{\mu^2 + (V^2 - \mu^2)\,0{\cdot}12 + (V - \sqrt{V^2 - \mu^2 + 0{\cdot}94})^2}$$

If we make $V = 2\mu$, we shall have $U_{t'} = 0{\cdot}71$.

This theoretical co-efficient of useful effect cannot be practically attained. It is impossible to make the term $\frac{Q\,M}{g}\,\frac{a^2}{2}$ zero in relation to the entrance of the water into the turbine. It is also necessary to take account of all the losses of *vis viva* arising from throttling angles and friction during the passage of the water, from its entrance into the ship to its exit.

Having regard to these different causes of loss of work, the practical co-efficient of useful effect, U''_t, will be some fraction of the theoretical one.

We shall therefore have

$$U''_t = A\,U'_t,$$

A being a constant co-efficient, the mean value of which, judging from what is generally the case in hydraulic machines, may be taken at 0·85.

10. In order to obtain the final co-efficient of useful effect of this propeller, it will be necessary to multiply U_t, of which we have spoken in sections 5, 6 and 7, by the co-efficient of useful effect belonging to the hydraulic machine, so that this final co-efficient of useful effect will be

$$U'''_t = U_t \times U''_t = U_t \times A\,U'_t.$$

In each particular case we shall adopt for these values of U_t and U'_t those found above.

If we adopt the arrangements referred to in section 5, which are those of the *Waterwitch*, and if the velocity of discharge V_1 of the water be double that of the ship, we shall have $U_t = 0{\cdot}66$, and if for the turbine we make such arrangements as to have the maximum of effect, and if we have $V = 2\,\mu$, we shall have a final co-efficient. $U''_t = 0{\cdot}66 \times 0{\cdot}85 \times 0{\cdot}81 = 0{\cdot}45$, which is a very low, useful effect, and inferior to that obtained with the screw and the paddle-wheel.

With the arrangement referred to in section 6, this co-efficient would be lower still.

The most favourable arrangement is that referred to in section 7. We can in this case obtain a useful effect $U_t = 1$, and a final useful effect (with $V = 2\,\mu$).

$$U''_t = 1 \times 0{\cdot}85 \times 0{\cdot}71 = 0{\cdot}60.$$

This co-efficient of useful effect is about the same as those realised by the screw propeller and the paddle-wheel.

11. Recapitulating, we arrive at the following conclusions :—

In order that an hydraulic propeller may act under good conditions, it is necessary to arrange things so as to insure :—

a. 1st. That the water shall enter the ship in a horizontal direction, and parallel to the middle line plane, and from aft to forward.

2nd. That the orifices of discharge shall be situated either at the level of the load water line or below it.

3rd. That the water shall leave the orifices of discharge in a horizontal direction and parallel to the middle line plane of the ship, and shall have a relative velocity equal to that of the ship, that is to say, an absolute velocity equal to zero.

b. With regard to the hydraulic machine employed to draw the water from the sea and discharge it from the ship, that, if we make use of a turbine, the vanes shall have to be curved in such a manner that the water shall enter the turbine without shock, and that the ends of the vanes shall make a very acute angle (about 20°) with the outer circumference of the turbine.

It is necessary also that the turbine shall revolve rapidly, so as to have a very high velocity at the outer circumference.

These conditions being satisfied, we can obtain with hydraulic propellers a mean co-efficient of 0·60.

12. The *Waterwitch* has been fitted with an hydraulic propeller, of which we know the results.

We will proceed to examine if these accord with the theory set forth in the preceding sections.

In the *Waterwitch* we have:—*

Area of the orifices of discharge—

$$\Omega_1 = 6 \text{ sq. feet} = \overset{m}{0{\cdot}5538}.$$

Velocity of discharge of the water—

$$V_1 = 30\text{ft.} = \overset{m}{9{\cdot}135}.$$

Volume of water discharged in a second—

$$M = 5059 \text{ litres}.$$

Area of immersed midship section—

$$B^2 = \overset{m}{31{\cdot}85}.$$

Speed of ship—

$$U = 15\text{ft.} = \overset{m}{4{\cdot}57} = \frac{V_1}{2}$$

$$V_a = V_1 - U = U = 4{\cdot}57$$

Area of the openings admitting the water into the ship—

$$\Omega_o = 30 \text{ sq. feet} = \overset{m}{2{\cdot}769}$$

Velocity of the water on its entrance into the ship—

$$V_o = \frac{V_1}{5} = \frac{2\,U}{5}$$

In the *Waterwitch*, the openings by which the water is admitted into the ship open forward, and the water enters them horizontally.

This is the case considered in section 4; and we therefore have $R = \frac{Q\,M}{g}(V_1 - U)$, which gives us for the *Waterwitch*, R = 2,402 kilogrammes.†

The work required to propel the *Waterwitch* (independently of the losses of work due to the hydraulic machine itself), will be given by equation (11) of section 5. We shall therefore have—

$$L_m = R\,U + Q\,M\,h + \frac{Q\,M}{g}\,\frac{V_a^2}{2} + \frac{Q\,M}{g}\,\frac{(U - V_o)^2}{2}$$

For the *Waterwitch*, we have

$$h = 0\,;\ V_a = U\,;\ V_o = \frac{2}{5}U, \text{ and as}$$

$$R = \frac{Q\,M}{g}(V_1 - U)$$

$$= \frac{Q\,M}{g}\,U.$$

From which we get

$$\frac{Q\,M}{g} = \frac{R}{U}$$

* These data are taken from newspaper articles and engravings, and are perhaps not altogether exact. With more correct data we should be able to correct the calculations.

† Assuming that the resistance of ships is proportional to the immersed surface of the midship section, and to the square of the velocity, we shall have $R = K\,B^2\,V^2$, where K is a constant. If we make R = 2,402 kilogrammes for the *Waterwitch*, we find that K. = 3·61. This value of K agrees with the admitted value of this co-efficient in ships of the size and fineness of lines of the *Waterwitch*, which shows the correctness of our theory. It may be observed that, with this system of propulsion, it is very easy to determine the resistance of ships without having recourse to dynamometers.

On substituting this value of $\frac{Q\,M}{g}$ in the above equation, we shall have

$$L_m = R\,U\,(1 + \tfrac{1}{2} + \tfrac{9}{50})$$
$$= R\,U \times 1{\cdot}76$$

The co-efficient of useful effect would therefore be $U_t = 0{\cdot}57$.

We see that the greater portion of the loss of work arises from the too great velocity of the water when it quits the ship. The above co-efficient is still further reduced by the losses of work due to the hydraulic machine or turbine.

In the *Waterwitch* the vanes of the turbine, instead of being curved and arranged so that the water shall quit them in a direction almost opposite to that of the rotation of their extremities, that is to say, with a very low absolute velocity, have their ends normal to the outer circumference of the turbine.

Under these conditions the absolute velocity (b) with which the water quits the turbine will be given by equation (19) when we make $e = 90°$. We shall then have

$$b_2 = v_r{}^2 + V^2 \text{ and as}$$

$$v_r = \sqrt{V^2 - \mu_2}, \text{ we shall have}$$

$$b^2 = 2\,V^2 - \mu^2$$

This value of b^2 being substituted in the equation (18) we shall have

$$T = \frac{Q\,M}{g}\,2\,V^2$$

The useful work is $Q\,M\,\frac{\mu^2}{2g}$ as we have observed in section 9.

The theoretical co-efficient of useful effect for this turbine will therefore be $U'_t = \frac{\mu^2}{2\,V^2}$

In the *Waterwitch*, we have:—

D, the diameter of the turbine = $\overset{m}{4{\cdot}27}$.

Number of revolutions per minute, N = 42.

We have therefore $V = \overset{m}{9{\cdot}50}$.

The area of the sections of discharge through which the water quits the turbine is about 80 square feet. We have therefore $V_r = \overset{m}{0.68}$., and as we have $V_r^2 = V^2 - \mu^2$, we get $\mu^2 = 90$. We have therefore—

$$U'_t = \frac{\mu^2}{2\,V^2} = \frac{90}{2\,(9{\cdot}50)^2} = 0{\cdot}50.$$

The final co-efficient of useful effect in the *Waterwitch* would therefore be—

$U''_t = U_t \times A\,U'_t = 0{\cdot}57 \times 0{\cdot}85 \times 0{\cdot}50 = 0{\cdot}24$, a very low co-efficient, and one which must be attributed to the arrangements adopted for the propeller itself, with which we have a useful effect of 0·57, and for the hydraulic machine, with which we have a useful effect of 0·50.

These theoretical results agree with those realised in practice.

In the trials of the *Waterwitch*, in which the above results have been obtained, an indicated horse-power of 828 was realised.

The resistance, R, of the *Waterwitch* being 2,402 kilogrammes, and the speed $\overset{m}{4{\cdot}57}$. per second, the work developed by this resistance in horses of 75 kilogrammètres is 147.

The co-efficient of useful effect will therefore be $\frac{147}{828} = 0{\cdot}18$. By assuming the value 0.24, found above as the co-efficient of useful effect of the propeller, we should have as the co-efficient of useful effect of the engines $\frac{0{\cdot}18}{0{\cdot}24} = 0{\cdot}75$, which is a probable co-efficient for a marine steam-engine.

The results obtained in practice agree therefore with those deduced from theory.

13. Let us now endeavour to ascertain what results might be arrived at in the *Waterwitch*, by fitting this ship with a hydraulic propeller arranged as pointed out by theory.

The openings by which the water enters should be turned towards the stern of the ship; and we ought to have $V_a = V_1 - U = 0$; that is, $V_1 = U = \overset{m}{4{\cdot}57}$.

We have—

$$R = \frac{Q\,M}{g}(V_0 + V_1)$$

$$= \frac{Q\,M}{g} V_1 \left(\frac{2}{5} + 1\right)$$

And

$$R = 2{,}402 \text{ kilogrammes.}$$

We shall find from this, that the amount of water to be discharged in a second, M, should eqnal 3,500 litres.

The area of the orifices of discharge must then be

$$\Omega_1 = \frac{3500}{4.57} = \overset{m}{0{\cdot}76}.$$

With snch arrangements we should have, as seen in section 5, a co-efficient of nseful effect of the propeller equal to unity.

With regard to the hydraulic machine itself, by arranging it as explained in section 9, we are able to realise a co-efficient of useful effect $U'_t = 0{\cdot}71$, so that we should have a final co-efficient of useful effect of $0{\cdot}85 \times 0{\cdot}71 = 0{\cdot}60$, instead of 0·24, as in the *Waterwitch* with her present arrangements, that is, a useful effect exceeding that obtained in the *Waterwitch* in a ratio of 2·50 to 1.

Instead of having 828 horses' power indicated by the engines, it would be sufficient to realise 331. As we have already seen, this advantage may be obtained by making the area of the section of the orifices of dis-eharge 0·55 instead of 0·76. Bnt the quantity of water to pass through would be less, that is to say, 3,500 litres per second instead of 5,000; so that by using a higher velocity the turbine might be made smaller, and the machinery lighter.

ERRATA.—In the commencement of the preceding article in our May issne, although accurately copied from the manuscript, the following errata occurs:—

Page 115, for (1) $X = -\frac{Q\Omega_0^2\ V}{g}\left(\frac{\cos.\ \alpha_1}{\Omega_1} - \frac{\cos.\ \alpha_0}{\Omega_0}\right)$ read

(1) $X = -\frac{Q\,\Omega_0^2\ V_0^2}{g}\left(\frac{\cos.\ \alpha_1}{\Omega_1} - \frac{\cos.\ \alpha_0}{\Omega_0}\right) + Q\,P_0\,\Omega_0 \cos.\ \alpha_0 - Q\,P_1\,\Omega_1 \cos.\ \alpha_1$

for (2) $Y = -\frac{Q\,\Omega_0^2\ V_0^2}{g}\left(\frac{\cos.\ \beta_1}{\Omega_1} - \frac{\cos.\ \beta_0}{\Omega_0}\right)$ read

(2) $Y = -\frac{Q\,\Omega_0^2\ V_0^2}{g}\left(\frac{\cos.\ \beta_1}{\Omega_1} - \frac{\cos.\ \beta_0}{\Omega_0}\right) + Q\,P_0\,\Omega_0 \cos.\ \beta_0 - Q\,P_1\,\Omega_1 \cos.\ \beta_1$

for (3) $Z = -\frac{Q\,\Omega_0^2\ V_0^2}{g}\left(\frac{\cos.\ V_1}{\Omega_1} - \frac{\cos.\ V_0}{\Omega_0}\right)$ read

(3) $Z = -\frac{Q\,\Omega_0^2\ V_0^2}{g}\left(\frac{\cos.\ \gamma_1}{\Omega_1} - \frac{\cos.\ \gamma_0}{\Omega_0}\right) + Q\,P_0\,\Omega_0 \cos.\ \gamma_0 - Q\,P_1\Omega_1 \cos.\ \gamma_1 + \pi$

ON THE IMPROVED COMPOUND ENGINES AS FITTED ON BOARD H.M.S. "BRITON."

By G. B. RENNIE, Esq., M. Inst. C.E.

The importance of economy of fuel is so great on board ships generally, and especially in a man-of-war, that the Admiralty were induced, I believe, throngh Mr. Reed's (late Chief-Constrnctor of the Navy) snggestion, to try an improved form of engine, adapted for using high pressnre steam, combined with means of working it very expansively. The engines adopted were of the compound description, with the addition of an arrangement for re-heating the steam on its passage from one cylinder to the other, after Mr. Cowper's plan. They were fitted on board H.M.S. *Briton*, one of the improved *Amazon* class of corvettes, the nominal horse-power being 350, capable of working, with 60 pounds of steam in boilers to 2,100 horses. The almost universal adoption for ship purposes of direct-action engines, which usually mako at least some 50 revolutions per minute and frequently more, necessitates the valve for cutting off the steam to be of a sliding kind; hence, when it is desired to have great expansion, some such arrangement as that of compound engines must bo employed, which permits the steam being first expanded to its utmost in a small eylinder, and then fnrther expanded in a large one; thus, supposing it is required to expand the steam 15 times, this is accomplished by making one cylinder three times the capacity of the other, and applying a sliding-expansion valve on the small cylinder to cut off the steam at one-fifth of the stroke, which is to be afterwards expanded in the larger cylinder. The engines of H.M.S. *Briton* are thus made. The smallest cylinder is 57in. diameter, and the larger 100in. diameter; the stroke of piston in both, 2ft. 9in. The smaller cylinder is fitted with a sliding-expansion valve, to cut off at from one-third to one-fifth of the length of stroke; bnt in order to have the advantage of the cranks of the two cylinders being at right angles to one another, the steam is not discharged direct from one cylinder into tho other, bnt there is an intermediate ehamber or reservoir between the two cylinders, into which the steam is received from the small cylinder and discharged into the large one. This chamber is made of copper and brass, and re-heats the steam within by means of a steam-jacket. On the official trials of these engines, the pressure of steam in the boilers was about 60 pounds per square inch, and the vacuum in condenser from 27 to 28in. Under these conditions, it was found that the power developed by each of the two cylinders was practically identical, and the same pressures were exerted at half-stroke when working "full power." The power obtained at "full power" was 2,148 horses, giving a mean speed of ship of 13·128 knots on the measured mile at the Maplin. The consumption of fuel for six hours was 24,000 pounds at full speed, indicated horse's power being 2,018, equal to 1·98 pounds per horse's power per hour. The consnmption at a 10-knot speed with 1,100·4 horse's power, was 1·515 pounds per horse's power per hour; and with 660 horses' power, 1·3 pounds per horse's power per hour. Thus, for an engine on the system of the *Briton*, the consumption of best coal may be taken at 2 pounds per horse's power per hour, when developing about six times the nominal power; at $1\frac{1}{2}$ pounds per hour, when developing three times the nominal power; at $1\frac{1}{3}$ pounds per hour, when developing twice the nominal power. These results were obtained under the supervision of Mr. James Steil, Chief Inspector of Steam Machinery Afloat of the Navy. The coal in each case was carefnlly weighed in bags at the dockyards, the number of bags carefully counted, the stoke-hole cleared up before and after each trial, and the fires placed in the same state at the commencement and completion of the different runs; two sets of indicator figures were taken from both cylinders at each end every half-hour, and the revolutions of the engines were taken with a mechanical counter. In order to make a comparison of the consumption of fuel per day, and the number of days' steaming with different classes of engines of the best description, I have made the following table, supposing the bunkers to be of the same capacity as the *Briton's*, namely, to contain 240 tons of coal. I take the *Briton* engines at full power, at 2 ponnds per horse's power per hour; the usual type, with 25 pounds steam pressure in boilers, and with surface condensers and super-heaters, at $3\frac{1}{2}$ pounds, per horse's power per hour; the injection condensing machine, at $4\frac{1}{2}$ pounds per horse's power per hour; and the high pressure, as usually made, at 6 ponnds per horse's power per hour. These several quantities are about the average amount of coal burnt in each case, and the following table is made ont supposing that the same indicated power be developed with the tons weight of coal required per day of twenty-four hours, and the length of time it would take to empty the bunkers for each type of engine. Thus:—

Type of engine.	Per H.P. per hour.	Tons per diem.	Days and hours steaming with 240 tons of coal.	
			days.	hours.
1. Improved compound	2	43	5	14
2. Ordinary type, with surface condensers and super-heaters	$3\frac{1}{2}$	75	3	4
3. Ordinary injection	$4\frac{1}{2}$	97	2	11
4. High pressure	6	129	1	21

At the lower speed of 10 knots in the *Briton*, when the steam was expanded to its maximum extent of about fifteen times, the coal used per diem was at the rate of ouly $9\frac{1}{4}$ tons; this would allow for twenty-six days' steaming, which at 10 knots per hour would give 6,240 miles. This, of course, supposes the voyage to be made under the same favourable circumstances as the trial. I will now take the comparative case of a mail steamer fitted with geared engines, injection condensers, and super-heaters, with a working pressure of 18 to 20 pounds per square inch in boilers, and of the same supposing it to be fitted with engines like the *Briton's*. The average amount of coal burnt in the former case on the voyage was from 43 to 44 tons per diem. The capacity of the coal bunkers is 570 tons, which, at the above rate, allows for thirteen days' steaming. The speed at measured milo was rather over $12\frac{1}{2}$ knots, and at sea an average of $10\frac{1}{4}$ knots from port to port. The latter case with the *Briton's* engines, the power developed would be sufficient to drive the ship over 13 knots mean speed, and the consumption of fuel at

sea, according to the results obtained in one of the six hours' trials, giving a power equivalent to that obtained in the engines of the mail steamer at sea, was at the rate of 18 tons per *diem*; and allowing, say 20 per cent, additional, for a somewhat inferior description of coal and less efficient stoking, gives 21½ tons per *diem*, or just one half the present consumption. The actual number of days' steaming of the mail steamer throughout the year is about 140, so that the quantity of coal required per annum would be diminished by about 3,000 tons; and in consequence of the *Briton's* machinery being of somewhat less weight, and occupying less space than the present engine, and from the coal capacity of bunkers being reduced one-half in bulk for containing the same number of days of coal, there would be about 300 tons additional space for cargo; and as the vessels on this particular line make on the average five voyages out and five home, there would be some 3,000 tons available for freight throughout the year by the adoption of the *Briton's* engines.* It may be considered that there are disadvantages attending the use of the higher pressures of steam and great expansion, and that the "wear and tear" is considerably increased by its adoption. My own experience does not lead me to think so; and I should say there is somewhat less wear and tear than with the ordinary engines, as the pressures and strains are more uniform and less liable to sudden shocks. It was remarked, during the trials of the *Briton*, how easily and uniformly the engines worked, causing less vibration to the ship than in similar classes of vessels with the ordinary engines; but it is a difficult matter to make a comparison for so much depends on the relative workmanship of different machines and the care that has been taken of them by those in charge. Perhaps it may be said that better workmanship and supervision in the working is desirable, in consequence of the steam pressure being so much above that of the atmosphere in the small cylinder, and always below it in the large one. In conclusion, I think I may safely say that the "compound" system of engine has been a gradual but marked step in the improvement of steam-ship propulsion with respect to economy of fuel; as important as the "injection" condenser over the simple high pressure—discharging the used steam into the atmosphere, or the surface condenser over the injection, and may be compared to the progress of organisation in animal life, where the higher the organisation the more delicate is its nature.

Magnetism has been defined as the ordinary attraction existing between the particles of a mass of matter,* but arranged polar, that is, with all the forces having the same direction, the force of attraction being exerted in a certain direction, a series of which attractions, arranged in the same direction, constitutes polarity. Polarity is a term which should be confined to the arrangement of the ultimate forces in a row or series, all the forces being in the same direction. A magnet is a good example of a polar solid, and magnetism should literally refer to, or be the abstract idea of, a polar solid. The attraction producing the phenomena of electricity of tension may cause magnetism; a flash of lightning will produce it; animal electricity will cause it; but the best mode of producing it is the disturbance of attraction produced by the voltaic battery, which compels its attractions to assure a polar state. When a body is magnetic and its attractions are disturbed it may lose its magnetic or polar condition. Hence percussion may destroy a magnet; lightning may destroy it; the voltaic force may be made to destroy it; heat may destroy it; and, lastly, one magnet may destroy another—because in these cases the attractions which were before polar become undefined as to any certain direction. In a parliamentary paper No. 118—1866, I find it stated that—

"The attention of the Fellows of the Royal Society has been recently directed to the very great increase which has taken place in the employment of iron in the construction and equipment of ships, and the consequent augmentation of the embarrassments occasioned in their navigation by the action of the ship's magnetism on the compasses. The inconveniences which have already made themselves felt in ships of the mercantile marine threaten to be productive of very serious loss of life and property unless remedial measures be adopted. Many recent losses of iron steamers have taken place in which it is probable that compass error has occasioned the loss." The Astronomer Royal in the first volume of our "Transactions" states that—"An iron ship exerts upon her compasses magnetic actions of two different kinds, both originally derived from the earth's magnetism. One of these is that which I have denominated sub-permanent magnetism, which for no inconsiderable time produces exactly the same effect as the permanent magnetism of a steel magnet, exerting constantly the same attraction on the compass, whatever be the ship's place on the earth and whatever be its position in that place. The other is the force of induced magnetism, depending always upon the relation of the position of the mass of iron to the direction of the terrestrial magnetic force, and changing its magnitude and direction instantly, according to well understood laws, when the position of the mass of iron is changed. The laws of the change of sub-permanent magnetism are not well understood." And in his recent work on magnetism† says that—"The principal agent in the disturbance of the compass is sub-permanent magnetism, an element little known before the introduction of iron ships." The means and method of correcting the sub-permanent magnetism by compensating magnets was introduced by the Astronomer Royal in 1838, and is still

Appendix.

Particulars of Trials of the Engines of H.M.S. *Briton*, constructed by Messrs. J. and G. Rennie.

Date of Trial.	Mean Speed of Ship in knots.	Pressure of Steam in Engine Room.	Revlutions per Minute.	Vacuum in Condensers	Mean Pressure per Square Inch on Piston. High.	Mean Pressure per Square Inch on Piston. Low.	Indicated Horses-power. High.	Indicated Horses-power. Low.	Indicated Horses-power. Total.	Total Quantity of Coal Consumed.	Coal Consumed per Horse-power per Hour.	Time of Steaming with 240 Tons.
1870.		Pounds.		Inches.	Pounds.	Pounds.						
19th May	13·126	54·5	95·25	27·	25·966	8·75	1,051·863	1,096·431	2,148·294	Not taken		
2nd June	12·767	51·91	92·649	26·57	25·299	8·383	996·5	1,021·8	2,018·3	24,000 lbs. in 6 hours.	1·98	5½ days.
10th June	10·026	50·	67·308	27·812	13·488	3·1	386·09	274·49	660·58	3,440 lbs. in 4 hours.	1·3	26 ,,
5th October	8·	43·166	60·25	28·3	12·612	3·462	322·97	274·233	597·203	4,000 lbs. in 4 hours.	1·674	22½ ,,
25th October	8·	43·71	60·195	28·0	11·537	3·4	295·93	269·98	565·91	3,800 lbs. in 4 hours.	1·68	23½ ,,
19th November	10·	47·33	75·321	27·54	17·15	5·558	549·39	550·75	1,100·14	10,000 lbs. in 6 hours.	1·515	13½ ,,

N.B.—Trials of May and June were made with Nixon's Navigation Coal; those of October and November with Fothergill's Aberdare Coal.

ON THE DEPOLARISATION OF IRON SHIPS.

By Mr. Charles F. Henwood.

The subject which I have now the honour of laying before you is the invention of the late Evan Hopkins, C.E., F.G.S., now known as "Hopkins' System of Depolarisation," by which the magnetism of an iron ship—the principal cause of the deviation and consequent depreciation of the compass—is completely and permanently removed. The science of magnetism had been Mr. Hopkins' study for upwards of thirty years, and he was the author of several works, among which that on "Geology and Magnetism" passed through three editions.

* The *Pera*, belonging to the Peninsular and Oriental Company, is the ship here mentioned. Since writing the above, Messrs. Rennie have received orders to make new engines for this ship on the *Briton* plan

* Matter being defined as that which attracts; that which cannot attract not being matter.

† A Treatise on Magnetism, Macmillan and Co., 1870.

retained in use without alteration. He thus describes it in his recent work, page 117—"Conceive the ships magnetism to be resolved into two parts, one transversal to the ship, one longitudinal. When the ship's head is placed north or south the transversal force alone disturbs the compass, and the quadrantal disturbance vanishes; and the transversal magnetic part can be corrected by an opposite transversal magnet broadside on the compass, whose distance is determined without any calculations, simply by trying its effects at different distances till the needle points correctly. Then in like manner if the ship' head is placed east or west, the longitudinal magnetism only disturbs the compass as the quadrantal deviation vanishes there, and it is to be corrected by a longitudinal magnet broadside on to the compass tentatively applied. The effects of permanent or sub-permanent magnetism are now entirely corrected. . . so long as the ship's magnetism remains unaltered, and so long as she remains in the same region of the earth." But, "with a change of ship's magnetism, the error produced in the needles' direction will depend on the magnitude of the local terrestrial horizontal force—if a ship is in a part of the earth where the horizontal force is large the error of the compass will be small, but if the horizontal force is small the error of the compass will be large." The Liverpool Compass Committee in their second report say that "In high latitudes the earth's directive or horizontal force is small, and when it is further reduced by the opposition of the ship's magnetism it will readily be seen how weak must be the directive power which remains." And in their third report say, "In certain places and positions of the ship the steering compass has been found to be entirely destitute of directive power. Only those who have made it a subject of inquiry can form a correct idea of how large a proportion of the complaints respecting the compasses of iron ships have reference to their sluggishness and want of directive power."

They state also that "The original magnetism of an iron ship is frequently very permanent as regards direction, but is believed to undergo rapid changes in its amount, both in reality and in its apparent effect on the compass." It is now a fact well known that immediately after launching, the magnetism of an iron ship diminishes rapidly; one of the most instructive examples of this change was observed by Staff-Captain Evans and Mr. Rundell, in 1859, in the Great Eastern. In the first five days there was a decrease of deviation of 12° on some points of the compass, in seven weeks 19°, and in the first nine months of service afloat it amounted to 32° 10′, or nearly three points. Captain W. Williams, in his evidence before the Compass Committee, states that "He has commanded several steamers on the line between Valparaiso and Panama, and that with new vessels it generally took him six months before he could place much confidence in their courses." Whether the compasses be compensated or not the Astronomer Royal affirms that the change which the magnetism of the ship undergoes affects uncompensated and compensated compasses with equal injury. The recent loss of the *Crescent City* was attributed by her captain to errors in the compasses. The *Crescent City* was a screw steamer built at Dumbarton, 316ft. long, 35·3ft. breadth of beam, and 25·2ft. deep, 2039 tons gross register, and classed at Lloyd's November, 1870. She left New Orleans in January of this year for Liverpool, and struck on the Dhulio Rock, in thick and heavy weather, on the morning of the 8th of February, and soon afterwards sank with a valuable cargo of cotton and seeds and upwards of 100,000 dols. in specie. The *Crescent City* was thus hardly six months old; there can be no doubt, therefore, that the changing magnetism of the ship had upset and made her compass compensations utterly worthless. After a period of about twelve months the magnetism of iron ships assumes a more permanent character; the following cases illustrates this fact. The *Great Britain*: This extraordinary ship (say the Compass Committee) has been stranded, and strained, and altered, has traversed both hemispheres, and been for many years in active service, yet her lines of no-deviations are now much the same as Dr. Scoresby would indicate them to have been when she was upon the stocks . . . a proof apparently that no circumstances can permanently conceal or greatly alter the direction of an iron ship's original magnetism.

Staff-Captain Evans gives a striking example of the permanency of the magnetism of an old or well-seasoned iron ship after severe concussion in the case of the *Adventure* troop ship built in 1854. "This ship in the course of foreign service struck on a rock during a fog with sufficient force to tear away and crush in 20ft. of the stem and bow under water. Observations for deviations and horizontal force were made before proceeding on the foreign service, and after the injuries sustained had been repaired in dock, these observations, made with every accuracy, failed to denote any change." And in his recent publication states that:—"This permanency of character is found in all ships of the royal navy, notwithstanding the constant tremours they undergo by the firing and exercising of heavy guns, and when under steam at high speed, as also the occasional jars in docking. It has been asserted that the firing of heavy guns, affects the magnetism of the ship; but there appears to be no ground for this assumption."

At considerable distance from the stem compass errors may amount to 40°, and at 3ft. or 4ft. from the rudderhead to 100, 150, or even 180°; but such errors, the Compass Committee state, may be successfully compensated, and that this compensation equalises the directive power of the needle. And Staff-Captain Evans says that, "If the deviations are large in amount, the angular movement in azimuth of the ship's head is not represented by a similar apparent angular movement of the compass. For example, in H.M.S. *Warrior*, when her head changes by compass from S.S.E to S.S.W, or through an angle of 45°, the actual angular movement of her head by the horizon is seven points, or nearly 80°. This is of itself embarrassing to the seaman; also, in the same case, the earth's directive force has been reduced nearly one half by the antagonism of the ship's force with the head of those azimuths. This gives sluggishness to the compass and increases the effect of friction and other disturbing causes." He also gives the case of H.M.S. *Minotaur*, stating that, "The steering compass at a distance of 55ft. from the stern had the enormous amount of 62° deviation, and that with 62° deviation, ship's head north, there would be only one-tenth of the earth's directive force acting on the needle;" and adds, "To remedy evils of this magnitude, compensations by permanent magnets on the Astronomer Royal's early suggested plan become indispensable to equalise the directive power on all points of the compass." He states further that "The troubles and anxieties attending erroneous compass actions have produced a plentiful supply of professed remedies, prominent among which is that of cutting off the effect of the iron of the ship by some electrical or non-conducting medium." "If," he continues, "we cut off the effect of the disturbing cause in the ship, we are also cutting off the main supply, namely, the magnetism of the earth, which alone gives directive power to the needle." In illustration of this statement by Staff-Captain Evans, I cannot do better than quote from remarks made by Captain Selwyn, R.N. He says, "I wish you to remember a little instrument called the astatic galvanometer, in which two needles are placed with their poles opposite. The whole object of that arrangement is to produce a needle which oscillates extremely slowly, which has no directive tendency due to the earth at all, which will constantly point east and west, instead of north and south, and which is, therefore, most sensitive to any electric current passing round it. Now, when you take magnets and put them in a ship as correctives of erring magnets, what have you done? You have, it is true, rendered the compass insensible to the magnetism outside it, but you have not less done so with regard to the magnetism of the earth. Then with regard to the magnetism of the ship, you have made by your error an excessively sluggish compass, whose evils have been by no means exaggerated. So if you place, as is done in the present day in the merchant service, magnets under the deck, you have done precisely the same thing in another direction." Thus by the present system of adjustment by compensation the directive power of the compass needle is considerably reduced. Nor is that all, for the Compass Committee admit that "experience proves that magnetic compensation is seldom so perfect as to dispense with the necessity for a table of deviations even in short voyage ships, while in ships making long voyages the change is frequently so great as to make a deviation table worthless, except for first clearing the land." And Staff-Captain Evans states that "mistakes frequently occur in practice in the distinction of east and west deviations, by which the effect of the deviations instead of being corrected is doubled." The following cases taken from the Compass Committee's reports illustrate the inefficacy of the present system of compass adjustment by compensation:—"The *Astræa* was adjusted in the Clyde and a table of residual errors given, and sailed to the West Indies, the deviations corresponding with the table. On the home voyage the captain observed a change of nearly two points, and before he met with any bad weather. The difference was shown to be due to a reduction of the ship's magnetism by taking away the compensating magnet. There being no time allowed for readjustment, the magnet was again put in place, and she sailed to the *Mauritius* with deviation table, this being sufficient precaution for clearing the Irish Channel and getting sea room. It is stated that when to the south of the Cape of Good Hope, towards the end of October, the sun bore at rising by the steering compass N. by W." "The steering compass of a new iron ship, the *Harvest Home*, was carefully adjusted at Liverpool before she proceeded to the East Indies. On arrival of this ship at Calcutta the captain wrote to the owners as follows:—"My compasses acted very well until I entered the 20° of south latitude, when the binnacle compass commenced to deviate considerably. I found the greatest amount of deviation in 39° south and from 25° to 45° east longitude, the binnacle compass then being $7\frac{1}{2}$ points out (or 84°)." As to errors arising from heeling, the committee truly state they are among the most perplexing which demand a captain's attention. In the "Admiralty Manual" it is also stated that "This alternating force tends to produce an oscillation of the compass which sometimes becomes extremely inconvenient." Capt. Williams in his evidence says, "The error from heeling

is the worst of the whole to correct for and to guard against its effect. The chief difficulty is to keep the ship on a given true course from headland to headland or from light to light; indeed, it is impossible to do so, as the course cannot be altered continually and simultaneously with every puff and squall that comes to put a crank ship over from 0° to 5° in this puff, from 0° to 10° in the next, may be, and so on to 16° to 20° heel, and that many times in a watch, thereby throwing the ship from her real course in a zigzag manner. It is the most difficult and perplexing error the shipmaster has to allow for in squally and changeable wind and weather, when trying to steer a good course to make the land. I have no doubt it has been the cause of the loss of many an iron ship. In the latest edition of the "Admiralty Manual" there is the following observation:—"It is to be remembered that more than ordinary watchfulness over the compasses of iron built vessels should be exercised to see that they are traversing freely, to remedy every defect in their movements, and to verify their deviations as frequently as practicable. [Should an arrangement of magnets be employed to neutralise these large deviations occasionally found and caused by the iron ship's magnetism, the compass so corrected can never be considered as entirely compensated, and the deviation must be expected to change on change of latitude and from other causes.] It will be thus seen that the mariner can have no absolute safe guide except in the system of actual and increasing observation." Thus we see that the magnetism of an iron ship is an element of very great danger to navigation, and especially so during the first twelve months of sea service; so great indeed in a new ship that the Astronomer-Royal recommends that "The ship should, if possible, be sent on a short voyage, or should be exposed to agitation by the sea and to tremour by her machinery in different positions of her head for several days, and should not be hurried out immediately for a long voyage." Now by the system of depolarisation the magnetism of an iron ship is completely and permanently destroyed, the compass is thus free from the principal cause of deviation, both when the ship is upright and when heeling, and this result may be obtained in course of a few days at comparatively trifling cost. The author here illustrated the system by placing a magnet at about 6in. from a compass, which caused a deviation of 30°; he then, in less than three seconds, destroyed the magnetism of the magnet by the system of depolarisation, which, when again placed in exactly the same relative position, had no effect whatever on the compass. The results already obtained both in England and abroad are highly satisfactory. I may mention the *Jeanie Douglas*, an iron sailing vessel of 1,200 tons. The owners say:—"The captain speaks well of the results of her depolarisation." The *Charente*, a French transport, was operated upon in July, 1867, and Admiral Dieudonné, chief of the Bureau Admiralty, Paris, writing under date 24th of March, 1868, says:—"The deviations of the compass of the *Charente* have not changed since you depolarised the iron which surrounded it, and the captain of that ship praises very much the results obtained. I have always had confidence in its success, and I believe that some day the process of Mr. Hopkins will be generally adopted." The captain of the *Charente*, under date, 9th of February, 1869, says:—"The compass (the iron surrounding which you depolarised) is the only one we can trust." It is right that I should mention that the first attempt to practically carry out this system of depolarisation was made by Mr. Hopkins on her Majesty's ship *Northumberland*, in January, 1867. The weather was extremely unfavourable and very cold, and Mr. Hopkins was at the time suffering from a very severe illness, which completely prostrated him before he was able to complete the operation. In spite, however, of these difficulties, the demagnetisation was carried on sufficiently far to prove the perfect practicability of the process, which was the main object of the experiment. It was found that the depolarisation of the armour plates had no appreciable effect on the compass, but that when the iron immediately surrounding the compass was submitted to the process great changes were at once apparent. In consequence of some of the iron beams being cased in wood, those only which affected the poop-compass and port-steering compass were operated upon. The results are recorded by Mr. Hopkins in the following table.

In writing to the Admiralty under date 25th of February, 1867, he said:—"This shows most conclusively that I had sufficient command over the disturbing magnetism of the ship, not only to reduce the deviation to zero, but also to change the deviation from east to west and *vice versâ*. It only required to carry on the process a little further to remove all the magnetism that causes the deviation, which would have been done had it not been for very severe illness and the inclemency of the weather at Sheerness. I have no one as yet trained to the depolarising business." Mr. Hopkins never recovered from the shock to his system sustained by exposure at Sheerness in the month of January, 1867, and died in the following May. Such being the melancholy termination of a life devoted to the search after scientific truth, it is with much pain and regret that I have to notice some adverse remarks made by Staff-Captain F. J. Evans, of the Compass Department of the Admiralty, since Mr. Hopkins' death. Addressing the Royal Society in March, 1868, he says:—"The process was in no sense of the word one of depolarisation, either of the whole ship or any part of it. It was, on the contrary, the polarisation to a high degree of intensity of a particular portion of the iron in the neighbourhood of three of the compasses. The process is in fact, not one of general demagnetisation, but of partial counter magnetisation." The statements undoubtedly show the "high degree of intensity of a particular" opposition, and the latter statement proves that Staff-Captain Evans does not correctly apprehend the subject, for, as a matter of fact, "depolarisation" is nothing more nor less than counter magnetisation, that is, one magnet destroying another. As further showing the character of this opposition I will quote a few extracts. The Compass

A table showing the deviation of the poop and port compasses of her Majesty's ship Northumberland, before and after depolarisation, as far as the process was carried on the 18th of January, 1867, at Sheerness.

Direction of the ship's head.	Original deviation of the poop compass.	Reduction by depolarisation — Poop compass.	Original deviation of the port compass.	Reduction by depolarisation — Port compass.
	deg. min.	deg. min.	deg. min.	deg. min.
North	16 0 E.	5 0 E.	20 0 E.	6 0 W.
N. by E.	7 0 E.	6 0 E.	12 0 E.	5 40 W.
N.N.E............	1 30 W.	7 0 E.	6 0 E.	5 0 W.
N.E. by N.	10 0 W.	7 0 E.	2 0 W.	4 30 W.
N.E.......	18 20 W.	6 0 E.	9 0 W.	3 0 W.
N.E. by N.......	25 20 W.	4 0 E.	17 0 W.	3 0 W.
E.N.E............	32 40 W.	3 0 E.	25 0 W.	3 0 W.
E. by N.	39 0 W.	0 0	31 0 W.	2 0 W.
East..............	44 30 W.	0 0	39 0 W.	0 0
E. by S.	48 40 W.	0 0	44 0 W.	0 0
E.S.E.	52 0 W.	3 0	49 0 W.	0 0
S.E. by S.	53 0 W.	6 0 W.	48 0 W.	0 0
S.E................	52 0 W.	9 0 W.	47 0 W.	2 0 W.
S.E. by S.	48 20 W.	10 0 W.	45 0 W.	0 0
S.S.E.	40 0 W.	10 0 W.	39 0 W.	0 0
E. by S.	26 40 W.	10 0 W.	30 0 W.	3 0 E.
South	12 40 W.	8 40 W.	20 0 W.	8 0 E.
S. by W.	0 30 E.	7 0 W.	8 0 W.	10 0 E.
S.S.W............	12 0 E.	5 0 W.	5 0 E.	12 0 E.
S.W. by S.	28 40 E.	3 0 W.	16 0 E.	13 0 E.
S.W.	31 40 E.	0 0	26 0 E.	12 40 E.
S.W. by W.......	38 0 E.	0 0	33 0 E.	12 0 E.
W.S.W.	42 40 E.	4 0 E.	36 0 E.	10 40 E.
W. by S..........	47 0 E.	7 0 E.	38 30 E.	7 0 E.
West	49 0 E.	8 0 E.	40 40 E.	4 0 E.
W. by N,.........	49 20 E.	7 0 E.	42 30 E.	0 0
W.N.W.	48 0 E.	6 30 E.	42 20 E.	0 0
N.W. by W. ...	46 0 E.	6 30 E.	43 0 E.	4 0 W.
N.W.	42 0 E.	6 30 E.	42 0 E.	6 0 W.
N.W. by N.......	37 20 E.	6 20 E.	32 40 E.	7 0 W.
N.N.W.	30 40 E.	6 0 E.	32 0 E.	8 0 W.
N. by W..........	23 30 E.	5 30 E.	26 20 E,	7 0 W,

Committee say of the *Nauphante*:—"The lines of no-deviation show by their peculiar curvature that a large portion of the disturbance is due to iron that is very near to the compass." Mr. Hopkins, speaking from experience, said:—"The principal disturbance proceeds from the effects of local masses of iron, and not so much from the hull, if the compass be 20ft. from the sides. We have recently had an example of the disturbing influences from internal masses of iron in H.M.S. *Dryad*, a wooden vessel with iron beams. This ship, on her return from a short trial near the entrance of Plymouth harbour, had a narrow escape from being wrecked, owing to the magnetism of her beams, which caused a deviation in her compasses of five and a-half points, or, say, 60° 30′." The *Dryad* is one of the "*Amazon* class," of 1,068 tons, builders' measurement, 300-horse power, and her breadth is only 36ft. Staff-Captain Evans also says*:—"The greater introduction of iron beams, decks, bulk-heads, and armour plating, has conducted to the great decrease of directive force of the compass needle in all parts of the ship. The average force is thus commonly reduced one-fourth from its value on shore, or in a wood built ship, or to three-fourths of its proper value; and the force when the ship's head is in direction opposite to that of her

* "Elementary Manual for the Deviation of the Compass in Iron Ships," page 109.

head while building is in many cases reduced to about one-third of that average, or to one-fourth of its proper value, and in some cases is even reversed."

Yet in addressing the Royal Society in March, 1868, he said :—" In an official report to the Admiralty of 31st January, 1867, I expressed the hope that, should further experiments be permitted in her Majesty's ships for depolarising their hulls, the so-called depolarisation should not be allowed within 20ft. of any compass that may be placed for the navigation of the ship," and speaks of being " impressed with the danger " of the system of depolarisation. Now, as a matter of fact, the only possible and probable danger likely to accrue by the adoption of the system of depolarisation is that of rendering the office held by Staff-Captain Evans liable to abolition, and the " Admiralty Manual " obsolete. The public, however, will consider such a danger as unworthy of consideration, in view of the safety to life and property at sea enhanced by the elimination of that acknowledged element of danger—an iron ship's magnetism—by the system of depolarisation.

THE MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this association was held at the Offices, 41, Corporation-street, Manchester, on Tuesday, April 18th, 1871, Hugh Mason, Esq., Vice-President, Ashton-under-Lyne, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, which referred to the visits of inspection and examinations made, as well as to the explosions which had occurred, from the 1st of January to the 24th of March last, the attention of the committee at the previous monthly meetings held this year having been occupied with other matters, so that reference to these subjects had to be postponed. This report, therefore, refers to the engineering proceedings during the last three months, of which the following is an abstract :—

" Since the 1st of January up to the 24th March inclusive, 659 visits of inspection were made, and 1,355 boilers examined, 968 externally, 18 internally, and 369 entirely, while in addition 6 boilers were tested by hydraulic pressure. Two of these hydraulic tests were ordinary ones, simply to ascertain the sufficiency of boilers already in work, while in the other 4 cases the boilers were new ones, and were tested by hydraulic pressure, as well as specially examined, both as regards their construction and complement of fittings, before leaving the makers' yard. In the 1,355 boilers examined, 265 defects were discovered, 34 of them being dangerous. Furnaces out of shape, 7—2 dangerous; fractures, 49—6 dangerous ; blistered plates, 24; internal corrosion, 53—12 dangerous ; external ditto, 26—7 dangerous ; internal grooving, 23—1 dangerous; external ditto, 8—1 dangerous; feed apparatus out of order, 3 ; water gauges ditto, 5; blow-out apparatus ditto, 12—1 dangerous ; fusible plugs ditto, 1; safety-valves ditto, 14—2 dangerous ; pressure gauges ditto, 12 ; boilers without glass water gauges, 1 ; without safety-valves 6—1 dangerous; without feed back pressure valves, 19 ; case of over-pressure, 1—dangerous ; case of deficiency of water, 1.

" Explosions.

" From the commencement of the year up to the 24th of March inclusive, the period to which this return is made up, 14 explosions occurred, killing 11 persons and injuring 10 others. Not one of the boilers from which these explosions sprung, was under the inspection of this association.

" In addition to this number of explosions from steam power boilers, four others have arisen from household boilers, killing one person, and injuring one other. The subject of the explosion of these boilers, is one of interest, but cannot be entered upon on the present occasion. It is a matter of congratulation that the view appears to be now gradually gaining ground that these explosions do not arise from the injection of a little water on to a red hot plate, but simply from accumulation of pressure through the stoppage of the outlets by frost or any other cause, so that the simple cure is a good safety-valve. Many safety-valves are now being adopted.

" It may also be stated that a fatal case of scalding took place on board a new steamer, just as her boilers and engines were being tried before leaving the maker's hands, through the slipping out of the steam pipe from an expansion joint consisting of a large stuffing box, in consequence of there being no retention stays, which, however, have been added since the mischief occurred. This disaster, by which the managing partner of the works at which the engines were constructed was killed, and seven other persons were injured, is very similar to one that took place on the Thames in the year 1844, on board the screw steamer *Gipsy*, scalding to death the constructor of the engines.

" Thus, including all classes, there occurred from the 1st of January to the 24th of March, 19 explosions, resulting in 13 deaths, and 18 cases of personal injury.

" In twelve out of the fourteen cases of explosions springing from steam power boilers, the scene of the catastrophe has been visited by officers of this association, and particulars ascertained. Details of the boilers in question, with the cause of their failure, will be found below. These investigations have shown, as on previous occasions, that however complicated are the results of explosions, the causes are very simple.

" These explosions suggest one or two considerations bearing on the subject of steam boiler legislation, now receiving attention. Firstly :—Out of the twelve explosions of which particulars were obtained, six arose from small boilers, showing that diminutive size is no guarantee against explosion, and that small boilers need inspection as well as large ones. Indeed, from their very smallness they are frequently treated with less respect, and therefore instead of being less dangerous, are more so than larger ones. Secondly :—That in most of the cases of explosion the owners were quite unaware of the danger to which they were constantly exposing themselves, so that, to such parties, a national system of inspection, mildly but firmly administered, would be a great boon.

" The following is the tabular statement of steam boiler explosions :—

" Tabular Statement of Explosions from January 1st, 1871, to March 24th, 1871, inclusive.

Progressive No. for 1871.	Date.	General Description of Boiler.	Persons Killed.	Persons Injured.	Total.
1	Jan. 2	Plain Cylindrical, Camber-ended. Externally-fired...	0	1	1
2	Jan. 2	Single-flued or ' Cornish ' Internally fired...............	0	0	0
3	Jan. 13	Plain Cylindrical, Egg-ended Externally-fired	0	3	3
4	Jan. 15	Particulars not yet fully ascertained	0	0	0
5	Jan. 16	Plain Cylindrical, Flat-ended Externally-fired	0	1	1
6	Jan. 26	Single-flued, or ' Cornish ' Internally-fired	2	0	2
7	Feb. 1	Plain Cylindrical, Flat-ended Externally-fired	1	2	3
8	Feb. 5	Marine. Particulars not ascertained	1	0	1
9	Feb. 15	Vertical Cylindrical Internally-fired	0	2	2
10	March 9	Double-flued, ' Lancashire ' Internally-fired	1	0	1
11	March 11	Single-flued, or ' Cornish ' Internally-fired	2	1	3
12	March 16	Plain Cylindrical, Flat-ended Externally-fired	1	0	1
13	March 17	Plain Cylindrical, Egg-ended Externally-fired	1	0	1
14	March 23	Single-flued, or ' Cornish ' Internally-fired	2	0	2
		Total	11	10	21

" No. 1 Explosion, by which one person was injured, but fortunately no one killed, occurred at about eight o'clock on the morning of Monday, January 2nd, at an ironfoundry.

" The boiler, which supplied steam to a small engine used for blowing the cupola, was of the plain cylindrical, externally-fired class, with cambered ends. Its size was diminutive, its length being only about 10ft. 9in., its diameter 3ft., and the thickness of the plates ⅜ths of an inch.

"The primary rent appears to have occurred at the bottom of the boiler, over the fire, where it traversed, in an irregular longitudinal line, the first belt of plates counting from the front end, and then, assuming a circumferential course, ran right round the boiler, thereby liberating the front end, and ripping away an entire belt of plating from the remainder of the shell. Added to this, other rents were started which reduced the boiler to fragments. On the occurrence of these rents the front end plate was blown forwards to a distance of about 70 yards, the boiler shed was demolished, the wall of the moulding shop belonging to the foundry, as well as a portion of the roof, knocked down, and the pattern shop behind the boiler house destroyed, while a portion of the *débris* was shot through the roof of the moulding shop, thereby injuring a young man therein, though fortunately not to a very serious extent.

"In explanation of the cause of the primary rent, it may be stated that immediately over the fire and at the first ring seam of rivets, there was a patch measuring 14½in. in the direction of the circumference of the boiler and 9in. longitudinally, and that this patch was seriously weakened by severe fractures running into the plate from nearly every rivet hole. From this patch the primary rent which resulted in the demolition of the boiler appears to have started. What the pressure of steam was could not be precisely determined, as parts of the safety-valve had been blown away and could not be found; but the owner stated that the ordinary working pressure was 25lb. on the square inch, and that the steam was blowing freely from the valve at the moment of explosion. The pressure gauge, which was of the dial class, was also found to be deranged, owing, it was said, to its having been frozen. It is thought that this explosion may be attributed to the defective condition of the boiler, consequent on external firing.

"This explosion affords a further proof that inspection is as necessary for small boilers as for large ones. Indeed, it may almost be said that small boilers are more dangerous than large ones, inasmuch as they are, as a rule, thought to be less worthy of attention, and consequently receive an inferior complement of fittings, are less accessible to examination, and do not receive such skilled attendance as others. In illustration of the above it may be stated that this boiler had no mud tap or other blow out apparatus, no feed back pressure valve, and no duplicate safety-valve. There does not seem any reason why a small boiler should not have two safety-valves as well as a large one, to ensure one valve being at work should the other fail. Added to this, the manhole was not strengthened as it should have been with a substantial mouthpiece, while the shell was not constructed for the purpose to which it was applied. It had been cut out of an old flue tube of an internally fired boiler, the longitudinal seams being in line, as is customary for such purposes.

"Although these circumstances may not have conduced directly to the explosion, they are of interest as evidencing the disrespect with which small boilers are too frequently treated, which cannot be unattended with danger. Attention may also be called to the fact that this explosion occurred at a foundry, and that the boiler was tended by the proprietor, who, it might naturally be supposed, would be somewhat of a mechanic, and therefore more competent than many to be his own inspector. It appears that he had just examined the float, and after ascertaining the adequacy of the water supply, walked a short distance from the boiler, when the explosion occurred, so that he narrowly escaped serious injury. The circumstances of this explosion seem to show that any national system of inspection competent to prevent explosions must embrace small boilers as well as large ones and not be conducted by self-elected inspectors. The plan that has been proposed, whereby every boiler owner would select his inspector according to his own liking, would not, it is feared, lead to efficient inspection.

"No. 2 Explosion.—As this explosion, which took place on Monday the 2nd of January, at a mine, did not result in any personal injury, nor, in any serious damage to property, it was not reported to the Association, but on the owners, shortly after, enrolling their boilers to prevent the recurrence of like disasters, the boiler from which the explosion sprung came under notice on the first visit of inspection. The particulars are very simple, and may be briefly given.

"The boiler, which was of the Cornish class, having a single furnace tube running through it from end to end, measured 32ft. in length by 6ft. 6in. in diameter, while the thickness of the plates was ⅜ths of an inch, and the pressure at which it was worked was stated to be 30 lbs. on the square inch. The boiler had given way in the furnace tube over the fire, rending at the ring seam of rivets uniting the first and second plates. On examination, the boiler was found to be seriously wasted by internal corrosion. Five of the plates were so thinned on one side of the shell that holes were knocked through in each case, while the furnace crown was so reduced that the plates were only ⅛th of an inch thick at the line of fracture. The cause of the explosion therefore was simply the weakened condition of the boiler from internal corrosion, of which competent inspection would have given timely warning.

"No. 3 Explosion occurred at an ironworks at about half-past four o'clock on the afternoon of Friday, January 13th, injuring three persons, but happily without fatal results.

"An officer of this Association visited the scene of the disaster to obtain particulars in the usual way. But as the explosion occurred in Scotland where such investigations are made by the Procurator Fiscal, he was not allowed to make an examination, though eight days had elapsed between his visit and the explosion, and thus an interval afforded which might reasonably be supposed sufficient to give the Procurator Fiscal ample time to take every particular. The same interruption has been met with on previous occasions, though after sending an officer all the way from Manchester. This obstruction is the more to be regretted as the Procurator Fiscal, though interfering with those who are willing to go to the trouble and expense of publishing reports on the cause of these disasters, does not do so himself, so that he robs the public of a service they would otherwise enjoy. Nothing has done more during late years towards the prevention of explosions than the constant investigation of the cause of these catastrophes, and the scattering broadcast the information thus acquired. It is to be regretted that governmental action should arrest so good a work. Unsatisfactory as the inquiries conducted by coroners with regard to the causes of steam boiler explosions have too often proved in this country, yet inasmuch as they have not prevented other investigations and reports thereon, they have been preferable to the secret system adopted in Scotland.

"On account of the interruption described above the information gained was incomplete, but the following facts were ascertained:—The explosion was a compound one, two boilers of the plain cylindrical, externally-fired class, set side by side, and constituting a series, having burst simultaneously. One of the boilers in question gave way at the last ring seam but one at the back end, the rent running right round the shell through the line of rivet holes. On the occurrence of this severance the back portion of the boiler was thrown backwards to a distance of about 80 yards, and the front portion forwards to about 200 yards. The other boiler was rent into a number of pieces longitudinally, and the fragments scattered laterally, one of them demolishing the engine house on one side, and two others falling on the other side at distances varying from 50 to 60 yards.

"The history of these boilers is somewhat interesting. It was only on the 18th of April in last year, that another explosion sprung from one of the boilers in this series. That boiler was replaced by one that had seen considerable service at other works, and was reported to have been about 20 years old, while the sister boiler, alongside which it was set, appears to have been about the same age.

"From the circumstances stated above, it was impossible to fully trace this explosion to its source, but from the treachery that has been found in other cases to be inherent in these plain cylindrical, externally-fired boilers, it may fairly be presumed that the explosion in this case was due to that cause, while it may be added that all the compound explosions that have come under my own observation have sprung from this class of boiler. Particulars of one compound explosion, in which five boilers exploded simultaneously, were given in the Association's printed monthly report for April, 1863. Another compound explosion, in which three boilers burst simultaneously, was referred to in the monthly report for March, 1862, while details of a third compound explosion, in which two boilers burst simultaneously, may be found in the report for March, 1864. The fact that a whole series of plain cylindrical, externally-fird boilers sometimes takes flight all together, is not an argument in favour of their trustworthiness.

"No. 5 Explosion, by which one person was slightly injured, but fortunately no one killed, occurred at five minutes past ten on the morning of Monday, January 16th, at a brewery.

"The boiler was of the plain cylindrical, externally-fired class. Its size, as in No. 1 Explosion, was very small, its length being only 8ft. 4in., its diameter 3ft., and the thickness of the plates ⅜ths of an inch, while the pressure at which the boiler was worked appears to have been nearly 50 lb.

"The boiler gave way at the front end plate, which was blown out, rending all the way round at its attachment to the shell, at some places through the plate itself, and at others through the root of the angle iron, by which it had been held. On the occurrence of this fracture, the main portion of the boiler was heeled over, and blown about thirty yards from its seat, where it alighted in a garden outside the brewery.

"The cause of the explosion was extremely simple. The boiler was badly made and quite unfit for the pressure at which it was worked. The ends instead of being hemispherical were flat, while the angle irons attaching both the front and back ends to the cylindrical portion of the shell were not in entire rings welded at the joints as they should have been, but in separate segments. The angle iron ring at the front end was in as many as three pieces, while two of the joints were not even

strengthened with butt strips. The ends though quite flat had no stays to strengthen them, and thus the safety of the structure depended upon these most decrepit angle irons, so that the boiler had been worked on at considerable risk for years. Added however to the original malconstruction of the boiler it had been further weakened by the ravages of external corrosion, which had so reduced the plates that at the primary rent the thickness was less than ⅛th of an inch for a length of nearly a foot. It is a matter of surprise that the boiler had not burst long before, while it is a matter of sincere congratulation that it had not done so when several persons were standing in front of it. This explosion may clearly be attributed to the weakness of the boiler consequent on original malconstruction, aggravated by the dilapidated condition into which it had been allowed to fall. Competent inspection could not have failed to have at once detected the danger, and prevented the explosion.

"It may be added that the boiler was not worked by its owner, but by a tenant, who only took possession about six months before, and states he had no idea whatever of the danger he was incurring. This fact is of interest as affording an additional illustration of the view previously expressed that many persons are risking their lives through working dangerous boilers simply from ignorance. It will not escape observation that this boiler, like the one from which No. 1 Explosion sprung, was of small size, while it may be added that the complement of fittings, as in that case, was stinted, there being no manhole mouthpiece, no feed back pressure valve, and no steam pressure gauge, while the boiler was very old, probably as much as 25 years. This explosion therefore is an additional proof that small boilers need inspection as well as large ones.

"No. 6 Explosion, by which two persons lost their lives, occurred at a farm, at about ten o'clock on the morning of Thursday the 26th of January.

"The boiler, which was of the internally-fired Cornish type, having a single furnace tube running through it from end to end, was of diminutive size, as in the case of two of the explosions already referred to in this report, its length being only 10ft. 1in., its diameter in the shell 4ft., and in the furnace tube 2ft. 4in., while the thickness of the plates was $\frac{5}{16}$ths of an inch, and the pressure of steam 40 lbs.

"The boiler, which was set on two side walls, gave way where resting on the left hand seating, the primary rent running in a longitudinal direction for a length of about 3ft. right across the central belt of plating, and then passing entirely round the shell through the line of holes at a circumferential seam of rivets. In consequence of this large rent the steam and hot water rushed out in a torrent, lifting the boiler from its seat, throwing the fireman to a distance of about 40 yards, the farm bailiff to about 10 yards, and killing both of them instantaneously.

"The cause was at once apparent on an examination of the boiler. The plates had been so seriously attacked by external corrosion where resting on both brickwork seatings that they were reduced for nearly the length of the boiler to the thickness of a sheet of paper, while in many places they were eaten into holes, so that the metal had gone altogether. In fact, the plates at these parts were completely riddled, and it must have devolved on the brickwork to keep the water in the boiler. It is clear that this boiler had been liable to explosion for some time past, whenever steam was got up, and that competent inspection would have discovered this danger in time to have saved the two lives that were lost.

"It should, perhaps, be explained that though this boiler gave way where resting on one of the side walls, that there is no objection to that plan of setting when properly carried out, and that it is far superior to the adoption of a midfeather. In this case, however, the seatings were twice as wide as they need have been, being 9in. instead of 4½in., while, as far as could be ascertained from an examination of the ruins, it appeared that the bottom of the side flues had been flat, and the boiler let down on to the solid brickwork, which rendered it very accessible to moisture. Instead of this the boiler should have been carried on suitable firebrick seating blocks. This has frequently been pointed out in previous reports. Members on setting new boilers or re-setting their old ones, should apply to this office, when a sketch, with instructions as to the best proportions of flues, &c., will be cheerfully sent them. Numbers of members have already availed themselves of this under similar circumstances, and found it to prove of considerable advantage to them.

CHEMICAL SOCIETY.

ON SOME SALINE COMPOUNDS OF CANE SUGAR.

By Mr. C. HAUGHTON GILL.

Péligot has described a compound of cane sugar and salt to which he ascribed a formula of $C_{24}H_{42}O_{21}NaCl$ ($C=6$, $H=0\cdot5$, $O=8$) which requires 14·92 per cent of sodic chloride: this indicates the replacement of 9 parts water by 58·5 parts of sodic chloride. Blondeau de Carrolles subsequently examined a similar compound, to which he ascribed the formula $C_{24}H_{20}O_{20},NaCl,3HO$, which includes water of crystallisation, of which Péligot makes no mention. Subsequently Mitscherlich denied the existence of the body, and Hochsteller mentioned that other chemists had failed to obtain it. Mr. Gill, being at first unsuccessful in preparing Péligot's compound by the method described, boiled a solution of sugar with an excess of salt for some time, filtered, and set aside the apparently uncrystallisable syrup. At the end of some months a few small, not very transparent, but individually distinct crystals had formed. They were drained, rinsed, pressed and analysed. The numbers lead to the formula $2(C_{12}H_{22}O_{11})3NaCl.4H_2O$. This compound of an unexpected composition having been obtained, a number of solutions of sugar with various proportions of different salts were made up and set aside to crystallise spontaneously in a dry air space, or in the gentle and regular warmth of a sugar-house working-floor. Where crystals were not obtained by these means a more rapid evaporation was tried, or an alcoholic solution was slowly evaporated, and, in many cases, these and other methods were tried with liquids neutral, alkaline, and faintly acid. The salts employed were the chlorides of potassium, sodium, lithium, and ammonium, the bromides of potassium and sodium, and the iodides of potassium, sodium, lithium, and ammonium. In each case four solutions were prepared, having one, two, three, and four molecules of the salt to the double molecule of sugar, $2(C_{12}H_{22}O_{11})$. None of the potassium salts gave compounds of a definite composition. The mixture containing the chloride in the smallest proportion gave crystals of pure sugar,—those containing the two largest proportions gave a crop of the pure potassic chloride. From the solution containing $2KCl$ to $2C_{12}H_{22}O_{11}$, anhydrous crystals containing from 1·3 per cent to 19·6 per cent of potassic chloride slowly separated, leaving behind a mother liquid of the consistency of treacle.

The solutions containing potassic bromide behaved in a very similar manner, giving crystals often very clear and sharp, and sometimes 5 or 6 m.m. in extreme dimensions, but always anhydrous and of irregular composition.

Different specimens contained such proportions of potassic bromide as 24·8, 19·15, 16·17, 12·0, 7·56, 28·15, and 22·3 per cent. In appearance the crystals could not be distinguished from those of pure sugar. The solutions containing potassic iodide evaporated to very thick sticky masses, somtimes containing a number of minute crystals which could not be separated from the mother liquor,

The sodium salts gave more definite results. In the case of the liquid, the solution containing least salt first gave crystals of pure sugar, and then, on further concentration, deposited crystals which are, doubtless, the same as those of the compound examined by Péligot, and are identical with those obtained from the liquid containing the next higher proportion of salt, viz., $NaCl$ to $C_{12}H_{22}O_{11}$. This compound crystallises in prisms terminated by pyramids: is very soluble in water, less so in spirit. From its solution in hot spirit of 85 per cent anhydrous crystals containing from 5 to 10 per cent of sodic chloride are deposited on cooling or slow evaporation. When to its solution in spirit of not more than 75 per cent ether is added, an oily layer is formed at the bottom of the vessel, and in this crystals form which have the composition $C_{12}H_{22}O_{11}.NaCl.2H_2O$.

The solutions containing sodic bromide can hardly be made to crystallise at all. A small quantity of minute confused crystals were deposited after some months from the solution containing $3NaBr$ to $C_{12}H_{22}O_{11}$; these, when pressed and dried over oil of vitriol, gave numbers which would point to a formula $NaBrC_{12}H_{22}O_{11}1\frac{1}{2}H_2O$, but it is more probable that when pure it is similar in composition to the analogous compound of sodic chloride.

The solutions containing sodic iodide give crystals of definite and constant composition with remarkable ease. These crystals always have the same composition whatever the proportions of the constituents in the mixture, unless one be in such large excess that it can in part crystallise out before the liquid becomes saturated with the compound.

The solutions containing a moderate excess of sodic iodide yield the best crystals and quickest growth. It can be re-crystallised as often as desired from water or dilute spirit without suffering decomposition, forming large transparent crystals even from small quantities of solution. Their constitution is expressed by the formula $2(C_{12}H_{22}O_{11}).3NaI.3H_2O$. None of the mixtures containing lithium gave any crystals other than those of sugar. Those containing a large proportion of the salt simply dried up to a gummy mass.

The mixtures containing ammonia salts gave no definite compounds. The chloride when in small quantity allowed sugar to crystallise out freely; when in large quantity it hindered crystallisation, but in time allowed the liquids to deposit well-formed, isolated, anhydrous crystals, generally opaque, but having the appearance of a definite body. These crystals, in fact, contained most variable proportions of ammonic chloride.

No results were obtained from the solutions containing ammonic iodide.

The crystals of sugar containing ammonio chloride and the equally distinct though generally smaller ones containing potassic bromide, and those deposited from a hot alcohol solution of the lower salt compound, must be built up by an anhydrous compound of the salt and sugar, isomorphous with sugar itself, crystallising out, together with an excess of the latter.

That the crystals are not simply sugar with adhering ammonic chloride is shown by their individual perfection and by the fact that they are deliquescent, whereas neither constituent is so.

The solutions of all the bodies described in this paper, especially that of the lower salt compound, exhibit persistent supersaturation in a remarkable degree. A saturated warm solution when cooled and shut up in an air-tight vessel with several crystals of the solid body, continues to deposit more of the compound for several months.

It is to be remarked that the sodium salts which give definite compounds are known to crystallise with two molecules of water when deposited at low temperatures, and that the iodide does so at all temperatures up to 20 per cent., whereas the corresponding potassium salts anhydrous at whatever attainable temperature they may be crystallised. The composition of the sodic iodide compound makes it seem probable that the true molecular weight of cane sugar should be represented by $C_{24}H_{44}O_{22}$.

The measurements of the various crystals mentioned in Mr. Gill's paper were kindly executed by Professor W. H. Miller.

The following gentlemen were elected Fellows—C. C. Grundy, S. B. Lee, G. Sutcliffe, W. Ward.

INSTITUTION OF CIVIL ENGINEERS.

ON THE ARCHIMEDEAN SCREW PROPELLER, OR HELIX, OF MAXIMUM WORK.

By Sir F. C. KNOWLES, Bart., M.A., F.R.S.

In considering the construction and action of the Griffiths' screw propeller, the author of this memoir was struck by the fact, that the blades worked in great part in the lateral streams of the water, and had no action in the dead water behind the sternpost, where power applied ought to be the most efficient. Again, in the common screw propeller, at all points near the axis, the power was almost wholly employed in churning the water, and in producing vibration by alternately lifting and depressing the stem, which no doubt induced Mr. Griffiths to limit the extent of his blades to points without that space. These considerations led to an endeavour to devise some form of blade which should be free from that imperfection, and yet on the whole possess the feathering property of the Griffiths' screw. But no particular form presenting itself which on principle could be pronounced preferable to any other form, the author decided upon proceeding to an *à priori* solution of the question, and assuming the existence of some best form, he was ultimately led to propose this problem, "What is the form of the surface of the Screw Propeller of which the 'work done' is the greatest possible?" The complete solution of this problem was the subject of the paper, and the following was an outline of the methods employed, and of the results obtained.

Referring the required surface to three rectangular co-ordinates x, y and z, one in the axis of rotation, the other two in the plane of rotation, the author first obtained a general expression for the total 'work done' by the blade in propelling the ship, in the form of a double integral in terms of the co-ordinates x and y and of the partial differentials of z with respect to each of them, of the speed of rotation of the blade, and lastly of the speed of the ship. As this integral was to be a maximum for all points of the surface sought, it must be treated by the known methods of the Calculus of Variations. This done an equation of condition was obtained, which, by the performance of the operations indicated by the symbols, led to an equation involving two factors, each factor being a partial differential equation between the three co-ordinates of the surface. The first of these being integrated gave for its solution the whole family of ordinary helices which were the surfaces of *least* work.

The second factor was the differential equation of the required surface, the treatment of which was given in the paper *in extenso*. It led at once, and very simply, to an equation analogous to that of the common helix $\left(\tan.\,^2\theta = \frac{a\tan.\,a}{r}\right)$ namely, $\tan.\,^2\theta = \frac{a\tan.\,^2a}{r}$ From this it was at once deducible, that the surface of the blade at the axis cut the plane of rotation at an angle of 45°, while the common helix cut it at 90°, and therefore acted powerfully in the dead water to propel the ship, just where the common helix had no propulsive power. It was proposed to call this surface the hemi-helix, or hemi-angular helix.

The paper then proceeded to determine the pressure of this blade upon the vessel in the direction of the keel, and thence the whole circumstances of the ship's motion. It was found that there was what was called "a slip," as in the case of the common helix. The author objected to this term, as involving a fallacious theory of the action of the screw,—in effect a denial of the equality of action and reaction. In order fully to expose the fallacy, the motion of a ship impelled by the common helix as a case of variable motion in a resisting medium was investigated, and, from the identity of the conditions and of their algebraical expressions it was proved that what was called "slip" of the screw was neither more nor less than "the ratio of the difference between the velocity which the ship would have in a non-resisting medium and its actual terminal velocity in the water to the former velocity." It was proposed, therefore, to substitute for this objectionable expression the term "ratio of resistance," or "relative resistance," as accurately representing the real phenomena, and measuring the efficiency of the given screw in propelling the given vessel.

The author was thus further enabled to explain what had been called "negative slip," and to assign its origin to the joint action of wind and steam, it being impossible in the case of steam alone.

FURTHER EXPERIMENTS ON THE STRENGTH OF PORTLAND CEMENT.

By Mr. JOHN GRANT, M. Inst. C.E.

In a previous paper the Author had stated* that "further experiments were desirable, on the strength of and adhesion between bricks and cement under varying circumstances; on the limit to the increase of strength with age; on the relative strength of concrete made with various proportions of cement and ballast," &c. The experiments described in this paper were made with the view of throwing additional light upon these points; and might serve to show those interested in the subject the direction which their inquiries might advantageously take, and the large field yet open for their labours. Before describing the new series of experiments, some of the points in the previous paper were reviewed. Among these were "the limit to the increase of strength with age," which Tables XVIII., XXIV., XXV., and XXIX. were intended to illustrate, and the experience of the last five years was given. Table XVIII. had contained the results of one hundred and sixty experiments, intended to extend over ten years, with Portland cement, weighing 123lbs. to the bushel. Neat cement, which at seven days broke at 817·1 lbs. increased gradually in strength, till at two years it bore a tensile strain of 1,324·9 lbs. By the extended Tables it was shown that the maximum had been attained at two years, and that the result was 1327·3 lbs. at seven years. With sand in equal proportions the increase in strength continued; that which at seven days broke at 353·2 lbs., at one month at 452·5 lbs., and at two years at 790·3 lbs., or 42, 50, and 60 per cent. of neat cement respectively; bore 818·1 lbs. at four years, 821 lbs. at five years, 819·5 lbs. at six years, and 863·6 lbs. at seven years, being about 65 per cent. of neat cement. Table XXIV. gave the strength of Roman cement at various stages from seven days to six years. The results did not uniformly and regularly increase. This cement bore a strain of 201·83 lbs. at seven days, 376.8 lbs. at six months, 323·8 lbs. at twelve months, 438 lbs. at two years, 450·8 lbs. at three years, 512·6 lbs. at four years, 466·9 at five years, and 466·6 lbs. at six years. The irregularities were very great, and confirmed the conclusion that this kind of cement was not nearly so uniform in strength as Portland cement, and that though two-thirds of the price it was only about one-third of the strength, and therefore double the cost of Portland cement measured by strength. Table XXV. related to another Roman cement, and brought down the experiments five years later. Cement which at seven days broke with a tensile strain of 202 lbs., and attained to its maximum 643·1 lbs. at twelve months, broke at 546·3 lbs. at two years, 603·8 lbs. at three years, 632·2 lbs. at four years, 627·4 lbs. at five years, and 666·4 lbs. at six years. Table XXIX. referred to Medina cement, which at seven days bore strains of 92·1 lbs. (1st series), and 211 lbs. (2nd series), attained a maximum strength of 476·9 lbs. at twelve months, and bore only 276 lbs. at two years.

As a preliminary to the further experiments hereafter described, upwards of two hundred were made to ascertain if the form of mould which had been previously used could be improved. The results of these were given in Table V. No. 1 was that which had been adopted at first (January, 1859), because found in use both in France and England. No. 2 showed the same size with the inner angles rounded off. Twenty

* *Vide* Minutes of Proceedings Inst. C.E., Session 1865-6, vol. xxv., p. 66.

moulds were made of each kind; ten were broken at seven days, and ten at thirty days. all having been kept in water. Forms 2 and 3 gave the highest results, and it was therefore presumed that No. 2, the form of mould shown in Plate 3 of the original paper, was of all these the least subject to error and irregularity. The later investigations of Mr. Bramwell, "On the Influence of Form on Strength," would lead to further experiments on this point. A large number of experiments had been made, as to the best mode of avoiding distortion from the line of strain. The plan originally adopted was shown on Plate 2 of the former paper. Another method was also shown on Plate 4, but it was found that moulds frequently broke at the holes in each end of the specimen instead of at the neck. The original form of clips was therefore reverted to, but in combination with knife-edges at each end of the clips.

The next step was to establish the conditions to be observed in the following new series of experiments:—A. On the strength of Portland Cement tested by tensile strain at different periods, from one day to twelve months, mixed by hand and ground in a mortar mill; B. On the adhesion between bricks cemented with Portland Cement and lime mortars, tested by tensile strain at the end of twelve months; C. On the strength of Portland Cement neat, and with different proportions of sand, tested at the end of twelve months, by compression in a hydraulic press. Size, 9in. by 4½in. by 3in.; D. On concretes of different proportions of Portland Cement and lime, with gravel, sand, and other materials tested at the end of twelve months by compression. Size, 12in. by 12in. by 12in., and 6in. by 6in. by 6in. For these experiments 38 bushels of Portland cement were procured; the gross weight being 4,300 lbs. 11 oz., or 113·176 lbs. per bushel. When sifted through a sieve of four hundred holes per square inch this was reduced to 4,201 lbs. 4 oz., or 110·56 lbs. per "striked" bushel. About 36 lbs. were afterwards rubbed through the sieve; 34 lbs. would not pass, and there was a loss of 29 lbs. A certain quantity of cement was sifted, when it was found that the gain, by sifting was about 14 per cent.

The following were the weights per bushel and per cubic foot of the materials used in the new series of experiments:—

Materials.	Weight of One Bushel.	Weight of One Cubic Foot.
	lbs.	lbs.
Portland cement	110·56	86·375
Sand and ballast	123·40	96·400
Portland stone	98·00	76·560
Broken granite	116·00	90·625
" pottery	113·00	88·280
" slag	107·00	83·594
" flints	126·00	98·440
" glass	120·00	93·750

Table VI., Series A., gave the strength of the Portland cement used throughout these experiments at different periods from on day to twelve months; first, mixed by hand, and next, mixed in a mortar mill for thirty minutes. In the first case the maximum strength seemed to have been attained at four months; in the second, at one month; the greatest strength of that mixed by hand was about double that mixed in a mortar-mill. The hand-mixed cement maintained its strength; the mill-mixed declined from its maximum at a month to the end of the experiments. This result was probably due partly to the process of crystallization, or setting, having been interrupted by the continued agitation, and partly to the destruction by attrition of the angular form of the particles. Table VII., Series B., on the tensile strain required to separate bricks cemented together with Portland cement and lime mortars, would require to be greatly extended before trustworthy deductions could be made from them. In the case of perforated bricks the cement mortar seemed to act as dowels between the bricks, and the results were consequently high. The Suffolk and Fareham red bricks adhered well to the mortar. Table VIII., Series C, on the strength of Portland cement bricks tested by crushing, was, so far as it went, very instructive. As a rule, strength increased with density. When the cement was in less proportions to the sand than 1 to 2 or 1 to 3, those dried in air bore a greater pressure than those kept for twelve months in water. This would lead to the inference, that when the quantity of cement was small, bricks or blocks of concrete should be kept some time out of water, to harden before being used. Contrasting the strength of these concrete bricks with different clay bricks, it was found that down to the proportion of 6 to 1 the former compared favourably. Thus, bricks made of neat cement bore a pressure equal to that of Staffordshire blue bricks or best Fareham red bricks. Bricks made in the proportions of from 2 to 1 to 6 to 1 of cement were equal to picked clay bricks of six varieties. The D series showed the strength of concrete bricks made with Portland cement, mixed with various materials in different proportions, and crushed after being kept a year, half of them in air and half in water. The general deductions were, that those made with the largest proportion of cement were the strongest, the strength being nearly in proportion to the quantity of cement. Tables were given of the strength of 12in. and 6in. cubes of concrete made with ballast, Portland stone, broken granite, pottery, slag, flints, and glass, mixed with Portland cement in the proportions of 6, 8 and 10 to 1, and compressed. Half were kept in water for twelve months. The most prominent result of these tables was that concrete made of broken stone or broken pottery, was much stronger than that made of gravel, due, no doubt, partly to the greater proportion of cement absorbed in the latter case in cementing the finer particles of sand, and partly to the want of angularity in the gravel. Compression and an increase in the proportion of cement alike increased strength. In making concrete bricks or blocks of moderate size compression might be applied with advantage; but with large masses of concrete it would be difficult to do so, without running the risk of interrupting the process of crystallization or setting, which commenced immediately, on the application of moisture. The cost of labour so applied would therefore be better employed in a larger admixture of cement. The different modes of using Portland cement in the construction of sewers were discribed: in some cases only as a foundation or as a backing for brickwork; in others sewers, 4ft. 6in. by 3ft., of concrete were lined with half-brick-work; and in other instances sewers were formed entirely of concrete in the proportions of 1 of cement to 6 of sand. The cost of this concrete was less than half that of brickwork, but if rendered inside with cement it was about the same as if lined with half brick—perhaps the cheapest form of sewer, combining strength with soundness. Sewers and culverts of almost any size might be made on this principle. Sewers made of concrete and not rendered inside, though somewhat cheaper, had one practical disadvantage in busy thoroughfares, inasmuch as they required a long length of centering, on account of the slow setting of the concrete, and it was therefore necessary that about double the length of trench should be open at one time. The cost of a concrete sewer, 4ft. by 2ft. 8in., was 10s. per lineal foot, exclusive of excavation. Under the same contract a brick sewer of the same size, 9in. thick, cost 16s. 6d. Another concrete sewer, 7ft. 1in. in diameter, cost 16s., or inclusive of earthwork, side entrances, junctions, &c., about 23s. per lineal foot. This sewer was in some respects exceptional, inasmuch as it consisted of little more than an arch over a previously existing invert; the lower half was however rendered with cement and sand, in equal proportions, 1in. thick. Everything being taken into consideration, the most economical combination was 4½in. of brickwork in cement and the rest in concrete. Another sewer, 9ft. by 9ft., of concrete, with a lining of 4½in. brick in cement was mentioned.

In the construction of the Albert, or Southern Thames Embankment, it was originally intended to form the wall of brickwork, with a granite facing; but after about a fourth part of the work had been executed, 14,335 cubic yards of Portland cement concrete made in the proportions of 6 to 1, at 11s. per cubic yard, were substituted for an equal quantity of brickwork, at 30s. per cubic yard.

From the experience already gained in the use of Portland cement concrete, there would seem to be hardly any limit to the purposes to which it might be applied. It was gradually being brought into use in the construction of dwelling-houses in different parts of the country, and there was no doubt it would be still more extensively employed in the construction of docks, piers, breakwaters, and other massive engineering works.

Many experiments had been made in the manufacture of bricks of different proportions of Portland cement and sand, and these were equal in strength and appearance to most kinds of clay bricks. Where concrete could be used in a mass, it was cheaper than when used in the form of blocks, and still cheaper than in the form of bricks. In 1867, a number of arches were formed with "Bétons Agglomérés," by M. Coignet, under the steps leading from Westminster Bridge to the Albert Embankment; also about 40ft. of sewer, 4ft. by 2ft. by 8in., in the Camberwell Road. Similar arches and sewers were constructed of Portland cement concrete, and the general result was that the Portland cement concrete was both stronger and cheaper than the béton.

Tables were given of the strength of 589,217 bushels of Portland cement used during the last five years on various works south of the Thames, showing an average tensile strain at the end of a week of 806·63 lbs., equal to 358·5 lbs. per square inch, being an improvement on that reported five years ago of 200 lbs. on the breaking area of 2¼ square inches, or 89 lbs. per square inch. The quality had not only been maintained, but had continued to improve. The strength at the end of thirty days of 37,2000 bushels of the same cement as ascertained by eleven

hundred and eighty tests, averaged 1,024 lbs., equal to 455 lbs. per square inch, showing an average of 234 lbs., or 30 per cent. over the cement tested at seven days, which broke at 790 lbs. Wherever the natnre of the work wonld admit of it, tests at the end of a month would be found more satisfactory than if made earlier, as heavy cements, though the strongest eventually, were the slowest to set. The standard originally specified was 400 lbs., on $2\frac{1}{4}$ sqnarc inches, and this was soon afterwards raised to 500 lbs., or 222 lbs. per square inch. This had since been increased to 350 lbs. per sqnare inch, or 787 lbs. ou the breaking area at seven days. For the purpose of comparison the same sectional area at the breaking point (2·25 sqnare inches) had been retained. Further experience had confirmed the earlier conclusions, that the strength of Portland cement increased with its specific gravity, its more perfect pulverization, and its thorough admixture with the minimum quantity of water in forming mortar. Heavy cement, weighing 123 lbs. a bnshel, like that referred to in Table XVIII., took about two years to attain its maximum streugth used neat; but by the admixture of sand or gravel, cement, mortar, or concrete was reduced in strength and set less rapidly than neat cement. Roman cement, though from its quick setting property very valuable for many purposes, deteriorated by exposure to the air before use; and was abont double the cost of Portland cement if measured by strength. In making cement concrete it would from this seem desirable to spend no more time than was absolutely necessary to effect a thorongh admixture of the cement with the sand and gravel.

A DESCRIPTION OF TWO BLAST FURNACES ERECTED, IN 1870, AT NEWPORT, NEAR MIDDLESBOROUGH.

By Mr. Bernhard Samuelson, M.P., M. Inst. C.E.

The author, having called attention to the enormons development in the production of crude irou during the last thirty years, now four times as great as in 1840, and having shown that it had increased three-hundred fold since 1750, at which time the whole annual produce of the United Kingdom was only equal to two-thirds of that of a single modern blast furnace, proceeded to describe the general arrangements of a furnace plant recently erected under his direction, and for his account, by Mr. Richard Howson, the resident engineer of the Newport works. The ironstone smelted was the ordinary argillaceous ore from the lias, containing, when dried, from 33 to 40 per cent. of protoxide of iron, and from 2 to 7 per cent. of sesquioxide of iron, equal to from 26 to 33 per cent. of metallic iron (increased by calcination to from 37 to 40 per cent.), and of from 20 to 25 per cent. of carbonic acid, 10 to 15 per cent. of silica, 10 to 15 per cent. of alnmina, 1 to $1\frac{1}{2}$ per cent. of phosphoric acid, in addition to 8 to 12 per cent. of magnesia and lime. The fuel was the hard coke of South Durham; the flux, principally monntain limestone. Whereas in three furnaces erected by him in 1854, for smelting the same ore, the quantity of fuel required to produce a ton of pig iron varied from 32 to 40 cwt., and in five furnaces erected in 1863-4 from 23 to 24 cwt., the coke consumed in these new furnaces was only 20·35 cwt. This great economy of fuel was due first, to greater capacity, augmented from 5,000 cubic feet in the earlier furnaces to 16,000 cnbic feet in those next erected, and to 30,000 cnbic feet in those forming this snbject of this paper. Secondly, to increased temperature of blast at the tuyères, which had been increased from 650° in the earlier to 1,100° in the later furnaces; and lastly, to increased regularity in working, the result of improvements of constrnction, all aiming at the greatest attainable simplicity and solidity. Drawings were shown exhibiting the relative sizes and the internal forms of the three types. The produce of pig iron from one of the latest furnaces, was stated to be from 490 to 500 tons per week. The works were so arranged that all the raw materials entered at one end, whilst the iron produced and the mineral trncks when empty, left at the opposite end, both being connected with the main line of the Stockton and Darlington Railway; and the western end also with a wharf on the River Tees, forming part of the works, at which vessels of from 600 to 800 tons were loaded. The trucks in their passage throngh the works were raised by a steam lift, consisting of an inverted cylinder 40ft. long, and 38in. in diameter, erected upon columns, from the piston of which a rod descended, and was attached to the lift by a cross head. The average gross weight of the trucks to be lifted was 14 tons; when they reached the top, they were run on to a high-level railway, which traversed a series of five calcining kilns and three boxes or bunkers for holding coke and small coal. The ironstone and limestone, and a sufficient quantity of coal for calcining, were discharged into the kilns, whilst the coke for the blast furnaces and a store of coal for calcining were dropped into the boxes. These boxes, like the trncks, were furnished with movable doors at the bottom, and discharged themselves without manual labour, except that of opening the doors. After the trucks were discharged, they descended by mcans of a drop, consisting of a platform, overbalanced by counterweights, so as to keep it at the upper level until the balance was inclined in the other sense by the weight of a trnck. The descent of the drop was controlled by a friction break. The kilns were cylindrical, bnilt up of wrought-iron plates and lined with fire-brick. The bottom was tapered, and had openings all ronnd for the admission of air and the withdrawal of the calcined stone, which was directed to the openings by a central cone, having its apex upwards. Each kiln had a capacity of 15,800 cubic feet, and held 630 tons of ironstone and limestone. From the kilns and bunkers the materials were carried in barrows to the furnace hoist. The entire lift was 92ft. The author considered this hoist as the simplest and most economical which had yet been constructed. It consisted of a main spur wheel 12ft. in diameter, erected on the platform connecting the two furnaces at the top, each side of the wheel being flanked by a grooved pulley carrying a steel rope $1\frac{1}{4}$in. in diameter. From opposite ends of these ropes two cages were suspended, which balanced each other, and were gnided by the columns supporting the platforms. The ropes passed only half round the pulleys, and were driven by their friction on the latter, so that whenever oue platform touched the ground, the weight being removed, the other conld not be overwound. Motion was given to the spur wheel and pulleys by a train of wheels connected with an 8in. double cylinder engine also erected on the furnace platform. Steam was conveyed to these engines from the boilers by a pipe 200ft. long, but being well covered the loss by condensation was trifling. The foundation of the blast furnaces was brickwork resting on clay; on this a circular base of solid brickwork, 7ft. in diameter, was erected, having a stone curb, an which were the columns, 18ft. 6in. high, which carried the upper part of the furnace, the lower part being supported partly by a wronght iron conical case, and partly by the brickwork and stanchions which surrounded the hearth. From the tnyéres upwards the furnaces were cased with wrought iron plates, varying from $\frac{3}{8}$ to $\frac{1}{2}$in. in thickness. The interior was lined with fire-brick lumps 5in. thick, backed with ordinary fire-bricks. The lumps forming the bottom of the hearth, which was 4ft. 6in. in thickness, consisted of two courses set on edge, and breaking joint. These lumps, as well as those forming the lining to within a short distance above the tnyères, were chisel-dressed on both faces and joints. The principal dimensions of the furnaces were:—Diameter of hearth, 8ft.; diameter at the bosh, 28ft.; total height from hearth to platform, 85ft.; depth of hearth at tnyères (four in nnmber), 3ft. 6in., diameter of bell opening, 13ft.; and cubical capacity, 30,085ft.

The pecnliar construction of the bell and hopper, an ingenions invention of Mr. Wrightson, of Stockton-on-Tees, was next described. The apparatns was used for charging the furnace, and for closing its top except when it had been opened for that purpose. All the waste gases were thus stored, conveyed by descending tubes to a main culvert, and thence by passages to the boilers and hot air stoves, where they met with the requisite proportion of atmospheric air for combustion, and served instead of coal, to raise steam and heat the blast. The temperature of these gases at the furnace-top was stated as varying between 315° when a charge of cold materials was first introduced, up to 634° before the next charge. The various valves for regnlating the admission of gas and air to the boilers and heating stoves, and for insuring their proper admixture, were shown and described. The heating stoves consisted of nine sections to each furnace, of which eight were always in use and a ninth cooling or being cleaned. The cast-iron heating-pipes were U shaped in elevation and oblong in cross section. There were twelve in each section, and their internal heating surface per furnace was abont 10,000 square feet. The air entered them from a cold blast main by valves, and was discharged into the hot blast main, which latter was lined with fire-brick 14in. thick to prevent radiation. From the hot blast main the air passed to the tnyères, and entered the furnace at a pressure of $3\frac{3}{4}$lbs. above that of the atmosphere. The four blowing engines, conpled in two pairs, which furnished 8,000 cnbic feet of air to each furnace, condensed to a pressure of $4\frac{1}{2}$lbs. per square inch above that of the atmosphere, were of the vertical construction now almost universal in Cleveland. The diameter of the steam cylinders, which were placed immediately over the blowing cylinders, was 32in.; that of the blowing cylinders was 66in.: the stroke of both being 4ft. The number of revolutions per minnte was 24; and the steam pressnre, cut off at a fourth of the stroke, was 55lbs. The steam was snpplied to these engines, to the donkey-engines which pumped water for the tuyères and the boilers, and to the hoist and kiln-lift, by seven Cornish boilers, 5ft. 6in. in diameter and 35ft. long, an eighth boiler being always kept in reserve. For the transport of the materials of these two furnaces and the removal of the slag two locomotives were required; the latter had wheels only 2ft. 6in. in diameter, and 5ft. from centre to centre, in order to pass readily round cnrves of small radius. The entire cost of the works, of which full details were given, was £56,331 4s. 4d., exclusive of land. The principal contractors were, for fire-lnmps, Messrs. William Stephenson and Son, of Throckley Works; for the heating stove-pipes,

Messrs, Smith and Thomson, of Stockton; for the boilers, hot-air valves, &c., Messrs. Cochrane and Grove, of Middlesbrough; for the blowing-engines, Mr. John Stevenson; Preston; for the gantry lift cylinder and slagging engine, Mr. Martin Samnelson, Hull. The author refrained from entering into the questions of the various reactions in the blast furnace and temperature of blast, or the merits of the regenerative heating stoves of Messrs. Cowper and Siemens, and of Mr. Whitwell, as compared with the cast-iron pipe stove adopted by himself, those snbjects having been already treated by Mr. Cowper, M. Inst. C.E., Mr. Isaac L. Bell, Assoc. Inst. C.E., and Mr. Charles Cochranc; but he presented the works described as an example of a plant fully equal to the standard of the present day, and in which no pains had been spared to combine the two great essentials in the construction of iron-works, durability and simplicity.

At the meeting of this Society on Tnesday, the 2nd of May, Mr. Charles B. Vignoles, F.R.S., President in the chair, twelve candidates were balloted for and declared to be duly elected, including three members, viz.: Mr. William John Bird Clerke, A.B., Trin. Coll. Dublin, Ex. Engincer, P.W.D., Bombay; M. Louis Joseph Aimé Thomé de Gamond, Paris; and Mr. Robert Piercy, Great Winchester Street Buildings. Nine gentlemen were elected associates, viz.: Mr. Herbert Chapman, Assistant-Engineer, Great Sonthern of India Railway; Mr. George Cooper, General Manager for the Contractors, Central Argentine Railway; Mr. Henry Tanner Ferguson, District Locomotive Superintendent, South Devon and Cornwall Railways; Mr. Druitt Halpin, Locomotive Department, Scinde, Punjaub and Delhi Railway; Mr. Hodgson Monteith Layard Jones, Old Broad Street; Mr. Charles Ferdinand de Kierzkowski, Great George Street; Mr. Walter Henry Maudslay, East Greenwich; Mr. James Rice, Assistant-Engineer, Madras Irrigation and Canal Company; and Captain John Lidstone Watts, R.E., Assistant-Secretary, Government of India, P.W.D., Calcutta.

The Council reported that, acting under the provisions of section III., Clause VII., of the bye-laws, they had, during the present session, transferred the following gentlemen from the class of associate to that of member:—Messrs. Benjamin Chapman Browne, Herbert Louis Augnstus Davis, George Eedes Eachns, Edward Gotto, Thomas Manson Rymer Jones, Algernon Joy, and Henry Shield.

ON THE TREATMENT OF TOWN SEWAGE.

By Mr. Arthur Jacob, B.A., Assoc. Inst. C.E.

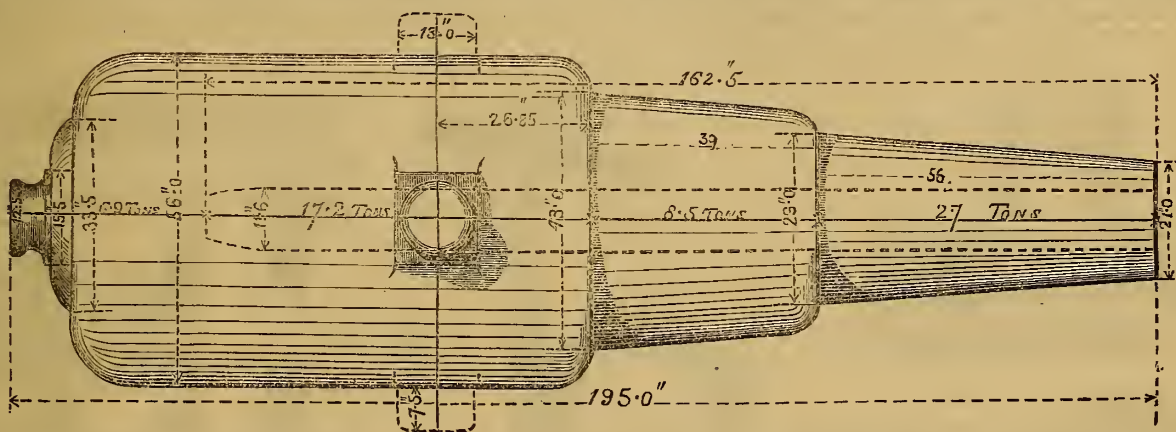
The treatment of sewage was divided into three heads, chemical, mechanical, and agricultnral. The chemical processes alluded to were, the Lime, the A B C or Sillars', the Northampton, and the invention lately introduced by Dr. David Forbes and Dr. A. P. Price. These, with the exception of the last-named method, had all failed to purify the effinent water from the works sufficiently to render it admissible into the natnral streams of the country, and were all more or less attended with nuisance in their operation. The process of Dr. Forbes and Dr. Price aimed at purifying sewage by the addition of mineral phosphate of alumina, which was found to exist in large quantities in some of the smaller West India Islands. The phosphate was calcined, treated with crude snlphuric or hydrochloric acid, and added in solution to the sewage. Milk of lime was next added, which disengaged the acid in the phosphate solution, and the deposit subsided. This system possessed the recommendation of prodncing a valuable manure, as contradistinguished from the A B C and other processes, in which the materials nsed had little, if any, agricnltural value. So far, experiments had shown that the effluent water resulting from the application of the phosphate process did not display much tendency to putrefactive change; but the inventors did not claim that the nitrogenous matters held in solntion were removed to any great extent, and suggested the employment of their method principally as an adjunct to irrigation, which was admitted to be the "most natnral and effective system of utilizing sewage." In the greater number of instances, the artificial modes of treating sewage had for their object the production of a solid manure; whereas what was necessarily desired by corporate authorities was the abatement of a nuisance, by depriving liquid sewage of its noxious constituents, and any system that did not accomplish this first essential was practically ineffectual. It was shown that chemistry and filtration, either singly or combined, had failed to accomplish the desired end, without almost total waste of the most valuable part of the sewage. In every case the greater part of the putrescible matter remained in solution, in a state more or less liable to decomposition. The efficacy of intermittent downward filtration, as recommended by the Rivers Pollution Commission in their report on the Mersey and Ribble basins, was considered, but was regarded as only admissible under exceptional circumstances, on account of the waste entailed by the process. The agricultural mode of dealing with sewage, namely—by irrigation, was advocated as at once effectual, consistent with sanitary requirements, and economical. In situations where land could be procured at a reasonable cost irrigation might be employed; it effectnally removed the dangerous impurities in sewage, and discharged the effinent water in a state practically pure into the watercourses of the country, and this could be accomplished without prejndice to the public health and without inconvenience to the senses. The process of irrigation was to a great extent independent of the state of the weather, being but little arrested either by continuance of wet or cold weather; and produced to the agricnlturist such results as no ordinary management could accomplish. The farms at Hornchurch, Barking, Croydon, and elsewhere, had furnished evidence of the large returns that irrigation, when judiciously managed, was capable of producing. The author maintained that irrigation was the only known process that had been found in practice to purify sewage completely. It was in no way injurious to health, and was calculated to prove a source of profit, with the exercise of reasonable care. Experience and existing examples had proved, that every description of land, when properly laid out and nnderdrained, was suitable for the reception of sewage. Althongh different soils prodnced various degrees of purification, all were found to appropriate the fertilising constituents of liquid sewage, so as to render the effluent water perfectly innocuous. The difficulties of procuring suitable land were sometimes considerable. Land should be selected with regard to the special circumstances of each case, rathed than with reference to the simple requirements of engineering expediency. The points specially considered were, the distance from urban districts, the proximity of the farm to a suitable market for the produce, and its relative position with regard to the direction of the prevailing winds. The objections raised to irrigation, as a means of propagating entozoic disease, did not appear to be supported by facts; but, being admitted, they could be met by the employment of the tar acids, which experiments had proved to be absolutely destrnctive to animal life in the form that objectors presupposed it to exist. If sewage irrigation was attended with the dangers apprehended, the same objection would hold to the employment of all ordinary kinds of manure. The determination of the area of land requisite for the treatment of the sewage of a standard number of people depended on so many circumstances that it could only be arrived at by experiment and experience. In each existing example there were varieties of circumstances that wonld influence the conclusion to be arrived at, sewage being sometimes strong, at others weak, and the soil free or compact in every possible variety, the determination of the reqnisite area would necessarily be varied accordingly, bnt so far as the determination of the question had been carried, the balance of opinion indicated a proportion of about one hnndred people of all ages to 1 acre of average agricultural land; much, however, depended on whether irrigation was employed merely as a mode of abating nuisance, or as a source of pecuniary profit. Irrigation was practised on the large scale in three different ways—by catchwork, when the surface of the ground afforded sufficient incliuation for the sewage to flow off; by the pane and gutter, when the surface inclination was but slight; and by ridge and furrow, or the bed system, when there was not sufficient surface slope to admit of the employment of the other methods. The latter was the most refined mode of applying sewage to land, and, although usually attended with more expense, there was much to recommend it; narrow beds were to be preferred to those of large size, as being more economical to form, and calculated to turn the sewage to the best account. The anthor advocated a considerable degree of filtration before discharging sewage over the surface of the ground, aud directed attention to the various forms of channels aud distributiug apparatus in use. Much prejndice existed against the employment of irrigation, because a dne degree of filtration had not usually been observed. It was therefore important that every precaution should be taken in details to render the priuciple of irrigation acceptable to the pnblic.

It was announced that the Presideut's Annunl Conversazione would be held on Tnesday evening, the 6th inst., when the co-operation of members and visitors was requested, iu order that a collection of models of engineering construction, of small and light pieces of Mechanism, and of Scientific Instruments, as well as of Works of Art, by ancieut and modern masters of eminence, depictiug some engineering work, object, or matter of interest, as "a bridge, lighthouse, aqueduct, or harbour, etc., set in its appropriate landscape," might be made.

At a meeting of the St. Pancras vestry a few weeks ago an application was received from the London and North-Western Railway Company for permission to remove a lamp in the approach-road to the Euston Railway station, in order that a statue of George Stephensou, the engineer, might be placed there. It was stated that the work would be carried out at the cost of the railway company and be a great improvement to the place. The application was unanimously agreed to.

THE WOOLWICH "INFANT."

We have the pleasure of laying before our readers in the accompanying engraving, the dimensions and weights of the new 35 ton gun, which from its enormons size, has earned the soubriquet which heads this article. As a plate (364) was given in THE ARTIZAN for September, 1870, together with an elaborate acconnt by Capt. F. S. Stoney, R.A., of the method of manufacturing heavy ordnance at Woolwich, but little description is now necessary. The gun here illustrated is the first of a series that has been designed for our coast defence, and is constructed in a precisely similar manner to those above alluded to, the only difference being in its dimensions. It is 3ft. longer than the 25 ton or 600-pounder gun, but somewhat less in diameter of bore; the 25-ton gun having a 12in. bore, while this gun only possesses a bore of 11·5in. at present. The rifling consists of 9 grooves, and the projectile intended to be employed is a "bolt" 27in. long, weighing 700lbs. or $6\frac{1}{4}$ cwt., and is fitted with metal studs to take the rifling. Since its completion it has been mounted in the Woolwich Marshes, for the pnrpose of undergoing the usual proof and experiments under the direction of the ordnance select committee, and will now be sent to the Shoeburyness School of Gunnery, to be tested as to range and accuracy. The proof was commenced with 75lbs. of pellet powder and gradually brought up to 130lbs., with this charge the pressure per square inch was fonud to be 40 tons, and the penetration of the shot in loose sand, 37ft. 4in. We believe the gun has been found rather too short to consume the large amount of powder that it was originally calculated to burn, but still it is anticipated that the range will be greater than that of any gun yet made. A new iron pier has lately been constrncted, fitted with a powerful steam crane for the purpose of shipping these heavy guns. And on the 11th ult., the first of a system of narrow railways (1ft. 6in. gange) was opened, for the transit of these and other heavy ordnance.



EXHAUSTING AND WASHING GAS.

ON A DIRECT ACTION METHOD OF EXHAUSTING, FORCING, AND WASHING GAS BY STEAM.

By Mr. WILLIAM CLELAND, of Linacre Gas Works.

This invention is named the direct action method of exhausting and washing gas by steam, because it aims at superseding in these operations the use of steam engines, and of exhausting and pumping machinery; by bringing the steam into actnal contact with its work. The retorts used in the destructive distillation of coal and cannel, being made either of coarse fireclay or of iron, and both kinds becoming very leaky by use, there wonld thus be a serions loss of gas if means were not nsed to prevent it. One of these means is exhausting, pumping, or sucking the gas from the retorts. A variety of exhausting machines are now in use. Some are rotary, and others are reciprocal and alternate in their action. The crude gas, as it passes from the retorts, is mixed with the vapours of tar, water, ammonia, and other condensable vaponrs. These are removed, to a great extent, by simple cooling in the condensers, and in the mains leading to the condensers. The condensers generally consist of a series of vertical pipes, the outlet of each pipe being connected to the inlet of the next in advance, and these connections being alternately t the top and bottom, so that the gas passes through them in a continuons up and down stream, the liquor of condensation flowing off from the bottom of each pipe. After passing the condensers, the gas still contains volatile salts of ammonia. These are generally removed by what is called scrubbing. The gas is passed upward in cylindrical vessels, through which a constant shower of water is distribnted, dissolving and carrying down with it the ammoniacal salts, the resulting solution being what is known as gas water, or ammonia liquor. The gas is passed in succession through two, three, or more of these "scrubbers," each provided with its pump and distribnting apparatns. The same water is passed through many times, until it is sufficiently charged with salts to be commercially valuable. After this hasty and imperfect sketch of the means hitherto used for exhausting, forcing, condensing, and washing gas, we may proceed to consider the direct action method. It is well known that a current or stream of any flnid, moving through any fluid medinm, produces, or tends to produce, aronnd itself a current in the fluid medium. For instance, if we blow from the mouth through a small tube, which projects into a larger tube open at both ends, the interior stream of breath sets in motion the whole body of air in the outer tube, causing at the further end a copious outflow, and at the near end an inflow. This effect has been termed lateral induction. The outer current is named the induced current; the exterior tube the induction tube; and the interior tube the projector. Snbstitute for the interior tube filled with air, a gas main of the proper diameter, filled with gas, communicating through the outlet with the gas-holder, and throngh the inlet with the retorts; substitute for the central jet of breath a jet of high pressure steam, and you have at once a working gas exhauster complete in all its essentials. The diameter, or the transverse sectional area, of the induction pipe is important; inasmuch as the power of the current in that pipe is directly proportioned to its velocity, and its velocity is inversely proportioned to its transverse sectional area. The induction pipe must be so contracted as to enable us to command a velocity equal to the highest pressure we may have to encounter. The length of the induction pipe in advance of the jet is also important. If too short, the stream of mixed steam and gas will not be confined enough, laterally to offer the necessary resistance to the back pressure, and to prevent an eddy or return current throngh the induction pipe. Its length must be proportioned to the maximum back pressure. The axis of the projector, of the induction pipe, and of the gas main into which the latter discharges, ought to be identical. The size of the steam jet, or of the orifice of the steam projector, of course depends on the quantity of gas to be passed in a given time, its resistance, and the pressnre of steam in the boiler.

In practice a projector with orifice $\frac{3}{8}$in. diameter, and a cylindrical induction pipe 3ft. long and 4in. diameter, have been found sufficient to pass 50,000 cubic feet of gas per hour, against a back pressure eqnal to 13in. of water, and to maintain a steady vacuum of 2in. in the hydraulic main. Besides the simplicity of this method of exhausting and forcing gas, and the small cost of the apparatns required, advantages which any one can see at a glance, there is another advantage which any one practically acquainted with the manufacture of gas will appreciate, namely, steadiness. The inflow and outflow being continnous and unchanging, so is the vacuum, and so is the pressure. It is subject to little or no irregularity, except what arises from irregnlarity in the supply of steam, and that irregularity no method of exhaustion can avoid. The case is very different with exhausters constructed on the pumping principle, or with any other exhansters in which the inflow and outflow proceed by gulps and surges; and to this objection nearly all other exhausting apparatns are liable. The necessity for controlling the steam engine and other machinery, and for checking or increasing their speed,

in order to increase or lessen their exhausting action, adds to the difficulty of securing a steady vacuum by any exhausting machine. If the vacuum is to low through lack of speed, the inertia of the fly-wheel and of other moving parts must be overcome before the speed can be brought up. If the speed is too great, their impetus is but slowly reduced. Hence the duration of such irregularities is necessarily somewhat prolonged. To make the advantage of steadiness apparent to all, it is necessary to glance at the arrangement and use of the hydraulic main. The hydraulic main is a gas main pipe placed in a horizontal position, and kept about half full of water. The pipes that convey the gas from the retorts are connected to its upper side, and dip into the water about 3in. The gas bubbles through this water, and passes over it to the main which leads to the condensers. A vacuum of 1 to $1\frac{1}{2}$in. is maintained in the hydraulic main, which reduces the pressure of the water by one-third or one-half. The remaining pressure or dip is held in reserve, to cover the risk of any accidental irregularity in the vacuum or in the level of the main; for, in the event of excessive vacuum occurring when the retorts are open, atmospheric air might be drawn in. Now, supposing the vacuum to be steady, and the hydraulic main to be level, as it is intended to be, we could with safety relieve the retorts of nearly the whole of the pressure produced by these 3in. of water. But as the vacuum is unsteady, we are compelled to work with a lower average vacuum, which, practically, means increased pressure in the retorts, increased leakage, less durability, and higher working expenses. Fig. 1 shows a longitudinal section of month pieces. *u* the inlet main. *v* the outlet main. Each of the induction pipes is provided with a slide valve. Thus each jet, with its induction pipe, forms a separate, complete, and independent exhauster, which can be used either singly or in conjunction with the others; one steam governor being arranged to regulate all the jets simultaneously.

The steam, having been employed in exhausting, has to be extracted by condensation, and to be made, at the same time, to wash the gas; that is, to perform the work of the water in the scrubbers. The general opinion seems to be that the purifying effect of the water is greatly increased by "scrubbing;" that is, by friction between the liquid and the gas. Accordingly it is sought to promote this friction by causing the gas to ascend through the scrubbing vessels, and meet the descending water. Now, although there is no doubt about the use of friction in such an operation as scrubbing a floor, the washing of gas is not at all analogous, and here its utility is questionable. The purifying effect is due to the solvent power of the water, and the operation is chemical, not mechanical. Looking at it as a chemical operation, there seems to be but one condition which is essential, viz., intimate contact between the water and gas; for even agitation and intimate mixture are only useful as means to effect the most intimate contact. Many observations, which cannot now be entered into, point to the conclusion that it is really so, and render more than doubtful the utility of friction. The water from the condensed steam carries down ammoniacal salts with it, and gives ammonia liquor. To bring this liquor to the desired strength,

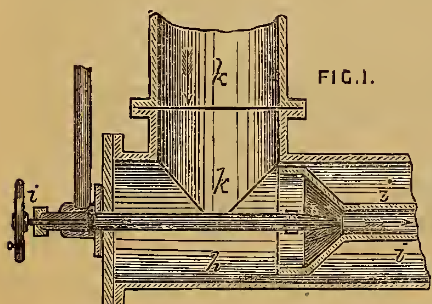


FIG. 1.

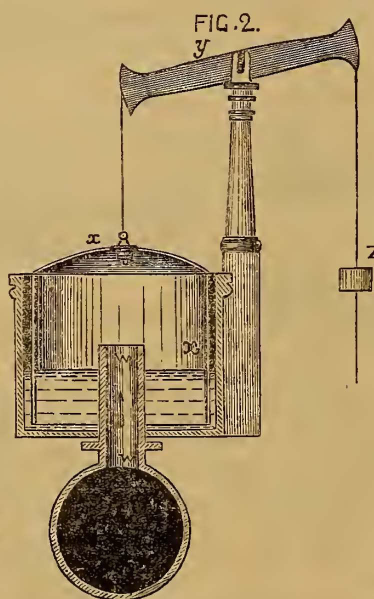


FIG. 2.

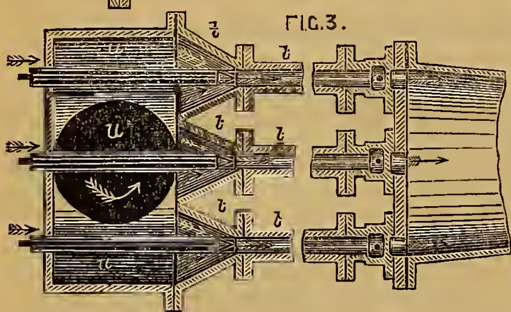


FIG. 3.

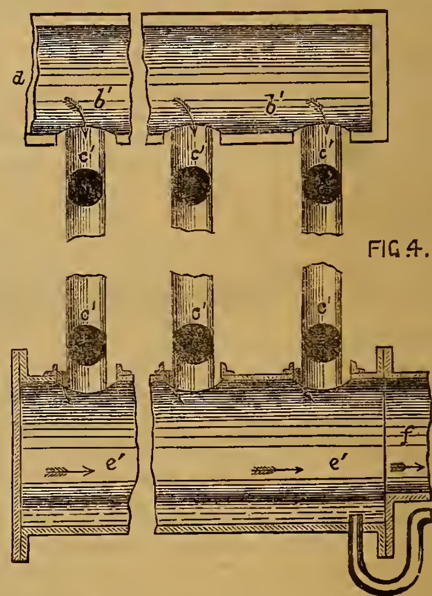


FIG. 4.

the direct action exhauster, the arrows pointing in the direction of the currents. *h* denotes the central steam injector, fitted with regulating stop valve, *i*. *j* induction pipe. *k k* are portions of the gas main. The supply of steam is regulated by a self-acting water governor (Fig. 2), which is the same in principle as those used with ordinary exhausters. The motion of the beam, *y*, is transmitted through the weighted chain and rod, *z*, which is connected to a wheel or lever, attached to the spindle of the regulating valve, *i*, which spindle, being fitted with a screw and nut of high pitch, opens and closes rapidly with the rise and fall of the governor. In the steam jet, or direct action exhauster, we have no machinery to control; the moving power being simply a jet of steam, acting directly on the gas, and the steam regulator acting directly on that jet, the effect of the regulator in raising and lowering the vacuum is instantaneous, and any tendency to irregularity is immediately checked. Another advantage of this exhauster is the readiness with which it can be adapted to a large or small production of gas. This can be done by the steam regulator itself, through the increase or decrease of the force applied within a wider range than is practicable with economy where engines and other machinery intervene. Should the production increase beyond the full capacity of the steam injector or of the induction pipe, two or more extra jets may be brought into operation, as shown in Fig. 3. Here we have three jets adapted to exhaust from one source and force into one outlet. *s, s, s,* are the steam injectors, with their regulating and stop valves. *t, t, t,* the induction pipes, with funnel-shaped it is only necessary to retard its flow, to spread it thinly over a large surface, and to keep it in contact with the gas until it has had time to dissolve its due share of salts. This can be done in a simple and inexpensive manner, by the use of apparatus, such as is shown in Fig. 4, which may be called a self-acting washing condenser. Either cast or sheet iron may be used for the construction of this apparatus. The last affords greater condensing power, greater internal capacity in the same space, and its lightness offers facilities for placing it in an elevated and airy place. *a* is the inlet leading to the compartment, *b'*; which it is well to protect by an air-jacket, or other suitable covering, to prevent the mixed steam and gas from condensing till they enter the vertical pipes, *c'*, so as to secure an uniform flow of condensed liquor through those pipes. *e'* is the condensed liquor compartment; *f* the outlet for the gas; *g'* the syphon outlet for the liquor. A large number of these vertical pipes, of relatively small diameter and considerable length, is to be preferred to a smaller number of large diameter, such as are generally used for gas condensers. Their united transverse area is much greater than the area of the inlet or the outlet pipe. Thus the gas, instead of passing rapidly through these pipes in one long continuous stream, and parting with its liquor as soon as it is formed, as is the mode in the usual gas condensers with vertical pipes, is divided into a number of slowly moving downward streams. Time is thus allowed for the cooling gas to circulate in currents produced by changes of temperature, so that it all comes within the influence of the cooling and washing surface while still

in the upper part of the pipes. There condensed liquor is chiefly formed, but not too copiously, and as it trickles slowly down the interior surfaces, the circulatiug currents still continning, through changes in tempera- tnre and specific gravity, the liquor has time to exert its solvent power on the ammoniacal salts, and to attain the desired strength before it reaches the liquor compartment. Condensation is also promoted by thus causing the gas to travel in an opposite direction to the ascending currents of air on the exterior of the pipes. Pipes of larger transverse area may be used with great advantage if occupied by some light and loose material, such as twigs, furze, or wood shavings, for the pnrpose of thoroughly breaking up the gas, and offering to it a larger washing surface, wet with condensed liquor. The apparatus thus becomes a set of self-acting condensing scrubbers, capable of yielding liquor of high degrees of saturation, without the aid of pumps, distributing apparatus, or any other machinery. I may add that this arrangement of con- densers offers very little resistance to the passage of the gas, in propor- tion to its condensing power. The ammoniacal impurities remaining in the gas after it has passed the steam condenser, may be removed in the purifying vessels by oxide of iron, sulphate of iron, or by other means now in common use. Shonld it be desired, however, to purify still fnrther from ammonia by washing, this may be done by the use of one or more extra condensing scrubbers, snpplied with fresh steam. In this case each of the jets of steam snpplying these extra scrubbers may be made to do its due share of the exhausting, so that these extra scrubbers ought to involve no extra consumption of fnel. Should the condensed liquor from the finishing steam scrubber be too weak to run into the general ammonia cistern, it may be passed, along with the gas, through the first condensing scrubber to take up more ammonia. The steam jet exhauster can be introduced, at little cost, into existing works, where scrubbers and condensers of the usual forms are already in use, pro- vided that there is sufficient spare condensing power for the steam. Fig. 5 shows the steam jet introduced into a connecting main or passage between two sets of gas condensers, or into one of the vertical pipes about the middle of a set of con- densers. The second set, or the second half, becomes in this case a steam condenser, and the weaker part of the condeused liquor is al- lowed to run into the service cis- terns of the scrubbers, to be worked up to the reqnisite strength.

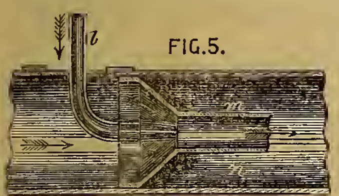


FIG.5.

REVIEWS AND NOTICES OF NEW BOOKS.

The Indian Civil Engineering College. Remarks by a Civil Engineer London: E. and F. N. Spon, Charing Cross.

This pamphlet, which, although the writer chooses to preserve his incognito, is evidently written by a civil engineer who has seen a good deal of service in India, and whose remarks, therefore, are entitled to respectful consideration, may be divided into two parts. In the first, the author treats upon the anomalous position of a civil engineer in a country where military engineers are very largely employed to perform precisely the same duties. Upon this point, he shows that the military man engaged in the P.W.D. possesses enormous advantages over his brother engineer, from the fact that he holds two appointments. Thus, to quote the words of the author :—"A military engineer knows, if he lives, no matter what mistakes he makes in civil employ, he must be a General of Engineers, and return to this country with rank and high social position. Besides this, he has superior pay for performing the same dnties which is explained by Colonel Alexander Taylor, Bengal Engineers:—26 * * * This excess is due to the military rank of the officers employed."

Many other advantages snch as "leave" and "pension," are also pointed ont as pertaining to the military department, but, we think we have shown enough to make it evident that so far as regards the inequality of the two professions, the writer has fully substantiated his case. As regards the new Indian Civil Engineering College, the writer considers that it is based upon wrong principles. In the first place. he considers the expense too great; secondly, that the class of pnpils that would most probably be obtained, would not have had a suitable preliminary educa- tion; and thirdly, that the salary offered to successful students is too low. In his opinion, the students should have already served an appren- ticeship or had some practical experience in engineering, and that they should be divided into three grades, according to the amount of such experience. With the anthor's remarks, respecting the necessity for practical experience, we cordially agree, as we do also with his opinion, that the remuneration should be considerably higher for first-class men. The writer is evidently well qualified to give his opinion on the subject, and we recommend all who are interested in Indian Public Works to stndy it for themselves.

Current Fallacies on Naval Architecture. By E. Gardiner Fishbourne C.B., Rear-Admiral, R.N. London: E. and F. N. Spon, 48, Charing Cross.

This treatise though only extending to twenty pages is, at the present time when the Admiralty appear to be "at sea" respecting the stability of our ironclads, very opportune. Coming as it does from the pen of one who is not only a naval officer of great experience, but who has also been deservedly considered one of the first authorities npou naval archi- tecture, it especially recommends itself to the careful perusal of all who are interested in this important question. It is to a certain extent a sequel to the anthor's treatise on the loss of the *Captain*, which was uoticed in The Artizan a few months ago. In the present work Admiral Fishbourne gives by the aid of diagrams, a simple exposition of the various points there treated npon, together with an explanation of the scientific terms used, so as to bring the treatise within the compre- hension of a non-professional reader. A pernsal of this pamphlet, will, we feel confident, be not without advantage, both to professional and non-professional men, who are interested in the future of our navy.

The Theory of Gunnery. By P. Anstruther, Major-General. Londou: E. and F. N. Spon, 48, Charing Cross.

This is a short brochure addressed to the Institntion of Civil Engineers, and calling in qnestion the correctness of the various mathamatical works and manuals at present nsed as guide books in the government military schools. The anthor appears to desire that scientific men free from prejudice, should test the accuracy of his conclusions, and therefore appeals from the military to the civil engineer. Thus, in paragraph 21 he says:—"We are obliged to appeal to the civil engineers, because the military engineers have not the means, the artillery have not the will to try the experiments reqnired." This is, no doubt, complimentary to civil engineers, bnt, we donbt if many, even if any, gentlemen belonging to that body conld afford not only the means, but the time required to carry ont experiments such as the author desires.

Elementary Principles of Carpentry. By Thomas Tredgold. Revised from the original edition and partly re-written by John Thomas Hurst. London: E. and F. N. Spon, 48, Charing Cross.

We gladly welcome a new edition of this favourite standard work. Since the last edition, as our readers are no donbt aware, vast strides have been made, both in the knowledge of the best methods of construc- tion of large works, and also in the discovery of new species of timber, some of which are pecnliarly adapted for especial purposes. Thus, as regards bridges, the Americans have employed timber for their constrnc- tion to a very large extent, in consequence of the cheapness of the material, and in their endeavour to attain this object, they have given ns some very fine new examples of the principles of carpentry. Then, again, our knowledge of the varieties of timber has been very much enhanced by the excellent specimens forwarded to the various international exhibi- tions from our colonies and other parts of the world, where bnt little was heretofore known of their qualities. We have, we fear, yet to find tim- ber thoronghly suitable for piles or sleepers in tropical climates, but mnch has been done, especially with the assistance of artificial preserva- tion to ameliorate the excessive destruction, to which earlier works con- structed with improper materials were liable. Upon the subject of timber, the present edition contains a great deal of valnable information, which, we consider, will be especially valuable to engineers engaged abroad.

The London Association of Foremen Engineers and Draughts- men held a meeting at the City Terminus Hotel, Cannon-street, on the 6th ult., Mr. Joseph Newton, (Royal Mint), President of the association, in the chair, a paper "On the Patent Laws" was read by Mr. W. Lloyd Wise, at which there was a large attendance, including several distinguished visitors, and the chairmau mentioned having received a letter from Mr. Johu Hick, M.P., regretting his inability to attend, in consequence of a prior engagement for the anniversary dinner of the Artist's General Benevolent Fund. Mr. Wise, in his paper, explained the existing practice relating to Letters Patent for inventions and sug- gested certain alterations whereby the abnses which have bronght the patent system, as hitherto administered into disrepute, might in his opinion, be corrected. A very interesting discussion eusned, in which Mr. Galloway, Mr. Webster, Q.C., F.R.S., Mr. Olrick, M. Inst. M.E., Mr. Conisbee, Mr. Campin, Mr. Young, Assoc. I.N.A., Mr. Ronald, (Wool- wich Arsenal), Mr. Briggs, and others took part, after which, the follow- ing resolntions having been dnly moved and seconded, were put and carried:—1. That the recognition of property in inventions contributes most materially to the wealth of the commnnity, and that the abolition of such property wonld be most injurions to the iudnstrial progress of the nation; 2. That the committee of the Londou Association of Fore- men Engineers and Draughtsmen are hereby reqnested to consider the desirability of appointing a deputation, to wait upon the chairman of the Honse of Commons committee, to submit the foregoing resolution, and to give evidence thereon if necessary. The proceedings terminated with votes of thanks to Mr. Wise and the chairman.

List of Applications for Letters Patent.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated April 11th, 1871.

948 W. B. Woodbury—Barometer
949 J. H. Johnson—Button holes
950 St. J. V. Day—Hydraulic presses
951 D. Horsfall—Preparing wool, &c.
952 H. Cartwright—Ploughs
953 J. Clark—Rolling iron, &c.
954 H. J. Madge and J. J. Jenkins—Tin plates
955 C. J. F. S. Macdowall—Knapsacks
956 B. J. B. Mills—Juices of meat
957 W. H. Smith—Handles of cutlery
958 C. Lenny—Raising carriage heads

Dated April 12th, 1871.

959 F. T. Aldridge—Hat bodies
960 F. Erskine and J. Harrop—Cutting hay
961 J. B. Breach—Cleaning saucepans
962 T. Halliday—Furnaces
963 R. G. Brook—Letter boxes
964 H. S. Sanderson—Blacklead
965 G. Siemssen—Indicating temperatures
966 M. L. Winn—Bathing the head, &c.
967 W. Nichols and W. S. Batley—Carrying plastic material, &c.
968 J. H. Johnson—Clothes wringers
969 W. Palmer—Dressing flour
970 J. Nixon and J. Winterbottom—Piercing tangs, &c.
971 A. V. Newton—Propelling apparatus
972 D. Jackson—Sulphuric acid
973 B. Bagshaw—Railway signals
974 A. V. Newton—Telegraphic communication

Dated April 13th, 1871.

975 J. Steel—Cooling liquids
976 W. Bradbury and H. Whittaker—Stillages
977 T. Cocker—Distributing fluids
978 R. A. Gooding—Printing checks, &c.
979 W. S. Laycock—Weaving
980 D. Greig and M. Eyth—Traction engines
981 G. W. Rendel—Torpedoes
982 R. Hornsby and J. E. Phillips—Ploughs
983 J. L. Chevelot—Oil projector
984 N. A. Delavigne—Iron stopper
985 E. T. Hughes—Whips
986 J. D. Shakespear—Ordnance
987 C. Morfit—Phosphates of lime

Dated April 14th, 1871.

988 W. Duxbury—Locking on railways
989 J. M. O. Tamin—Lever combination
990 A. Lafage—Camp bed
991 C. Wilson—Trucks
992 H. H. Murdoch—Refrigerating machines
993 G. Spencer—Preserving wheat
994 S. I. Redpath—Knitting socks
995 J. Townsend—Treating phosphates
996 A. Mackie—Perforations

Dated April 15th, 1871.

997 C. Morfit—Superphosphate of lime
998 W. Southwood—Feeding fires
999 E. R. Austin—Erecting cylinders, &c.
1000 G. and A. Jackson—Healds, &c.
1001 J. Tall—Roofs
1002 A. V. Newton—Stringed instruments
1003 T. Murcott—Firearms
1004 J. F. Lackerstern and J. C. Bromfield—Paper for cigarettes
1005 W. Mackinder—Wheels
1006 G. C. Perkins—Mattresses
1007 W. R. Lake—Raising air, &c.
1008 F. G. Fleury—Measuring liquids
1009 A. M. Clark—Treatment of bone, &c.
1010 A. G. Day—Elastic compound

Dated April 17th, 1871.

1011 G. Speight—Cleaning knives
1012 J. McNicol—Paper pulp
1013 T. J. Smith—Stretching frames
1014 J. Lawson—Machinery for flax, &c.
1015 W. R. Lake—Application of fibres
1016 J. T. Parlour—Framework
1017 W. R. Lake—Axles
1018 W. E. Newton—Holding shades
1019 W. E. Newton—Sash fasteners

Dated April 18th, 1871.

1020 A. Leneven—Hats
1021 R. and R. Bickerton—Harrows
1022 D. H. Saul—Bottles, &c.
1023 J. H. Johnson—Secret Correspondence
1024 J. Thomas—Puddling machine
1025 W. R. Lake—Plate for teeth
1026 A. M. Clark—Money-till lock
1027 Capt. A. Hamilton and J. Sax—Cabs

Dated April 19th, 1871.

1028 W. C. Eyton—Drying hides
1029 W. Conisbee—Printing machines
1030 W. Laycock and J. Riley—Fabrics, &c.
1031 W. Brookes—Rinsing wool
1032 W. Hughes—Sugar mills
1033 B. Harlow—Cast-iron pipes
1034 W. E. Newton—Supply of steam
1035 W. E. Newton—Mastics, &c.
1036 D. Spence—Purification of gas

Dated April 20th, 1871.

1037 A. Pilling and R. Nussey—Machines
1038 W. R. Lake—Photographs on glass
1039 C. Tysoe—Gassing yarns
1040 J. R. Forman—Valve boxes, &c.
1041 G. T. Bousfield—Cleansing fibres
1042 A. L. Normandy—Artificial cold
1043 E. Field and L. Oldrick—Safety-valves
1044 B. J. B. Mills—Removing oil, &c.

Dated April 21st, 1871.

1045 W. and C. Crighton—Cotton
1046 R. Norfolk—Preserving timber
1047 R. Eaton and B. Dunkerley—Stretching felt hat bodies
1048 M. M. Harris—Distilling
1049 W. W. Box—Manufacture of gas
1050 S. Cropper—Printers' rules
1051 J. Ellisdon—Contracting canopies
1052 P. Toepler—Cleaning cotton yarn
1053 W. N. Cox—Measuring water, &c.
1054 W. R. W. Sleigh—Signals
1055 E. Körting—Feeding steam boilers
1056 J. Harris—Ordnance
1057 T. Shakespear and G. Illston—Sewing machines
1058 W. R. Lake—Sewing machines, &c.

Dated April 22nd, 1871.

1059 W. R. Brown and R. L. Jones—Matches
1060 D. Ward—Construction of shears
1061 B. Sagar and T. Richmond—Machines
1062 T. W. Parker and J. Greenwood—Mules for spinning
1063 H. Ashton—Boilers
1064 G. R. Sweetser—Aerated liquids
1065 W. Thomas—Busks for stays
1066 T. Rowan—Obtaining steel
1067 T. Rowan—Manganese compounds
1068 W. I., T. and J. Holdsworth—Textile fabric
1069 B. Wrigley—Kilns
1070 W. W. Biddulph—Railway breaks
1071 J. Paterson—Treating pulp
1072 C. J. Appleby—Piercing holes in rock
1073 W. R. Lake—Boots and shoes
1074 W. R. Lake—Sawing stone
1075 E. F. Bradley—Brushes

Dated April 24th, 1871.

1076 A. M. Clark—Rotary motion, &c.
1077 J. W. Doble—Products obtained, &c.
1078 C. Pontifex, F. Pontifex and A. Sherwood—Washing casks
1079 H. E. Townsend—Nailing shoes
1080 T. A. Warrington and A. Minton—Brushes
1081 B. Hunt—Breech-loading rifle gun
1082 W. R. Lake—Water-wheels
1083 W. R. Lake—Utilizing wave power
1084 R. Irvine and C. N. Johnson—Phosphatic materials
1085 J. Hunter—Furnaces

Dated April 25th, 1871.

1086 J. and E. Woods—Drawing wire
1087 T. A. Skelton—Street lamps
1088 T. Unsworth—Making banding
1089 A. Zawadski—Octaves of organs
1090 W. Wormald and S. H. Hall—Sewing machines
1091 J. Gurrin—Mode of fastening
1092 A. Borgnet—Muffles
1093 C. Norris and J. Seed—Spinning, &c.
1094 E. Bull—Telegraph apparatus
1095 W. L. Wise—Horse-shoes
1096 W. R. Lake—Concentrating ores

Dated April 26th, 1871.

1097 J. M. Drouyer—Continual mincer
1098 J. Rigby—Fire-arms
1099 A. Grainger—Organs
1100 O. Ingram and I. Butterfield—Textile fabrics
1101 F. Claudet—Separation of silver, &c.
1102 W. Heeson—Furnace bars
1103 A. V. Newton—Electrotype moulds
1104 A. V. Newton—Cutting pliers
1105 A. M. Clark—Making moulds

Dated April 27th, 1871.

1106 R. Rogers, J. Mornington and J. Weston—Pianoforte backs
1107 W. R. Lake—Joiners' clamps
1108 J. T. Tannett, J. Craven and S. Fox—Cranes
1109 J. C. Ramsden—Looms for weaving
1110 L. J. Todd—Steam carriages
1111 G., H. and W. Harrison—Mules, &c.
1112 H. W. Harman and W. H. J. Mills—Indicating time
1113 P. R. Whitehead—Bleaching, &c.
1114 W. E. Newton—Fire-arms
1115 F. Bennett—Roofing tiles
1116 S. C. Lister—Treating yarns
1117 S. C. Lister and J. R. Gispert—Looms
1118 S. Brooke—Rubbing belts, &c.
1119 G. Heyes and T. Entwistle—Beaming machines
1120 C. E. and J. H. Bell—Condensers
1121 P. Robinson, W. Robinson and C. Skinner—Solid glass rings
1122 W. Page—Adjustable riddles, &c.
1123 T. Isherwood—Shuttles for looms
1124 J. Lambert—Composition, &c.

Dated April 28th, 1871.

1125 W. Pierce—Railway breaks
1126 R. Keevil—Milking cows
1127 W. E. Kenworthy and J. Johnstone—Consuming smoke
1128 W. R. Lake—Pocketbooks
1129 L. Clayton—Finishing yarn
1130 W. Knowles and J. M. Hetherington—Clearing rollers
1131 A. V. Newton—Street lamps
1132 H. W. Hart—Hats, &c.
1133 J. James—Construction of boxes
1134 J. Emmott—Preparing wool
1135 J. B. Spence—Furnaces
1136 J. B. Spence and P. Dunn—Manure
1137 S. S. Bateson—Fumigators
1138 J. Smith—Ordnance batteries
1139 H. E. Mines—Cooking ranges
1140 H. E. Mines—Lighting and heating
1141 H. Levy—Fasteners
1142 S. Corbett—Ploughs
1143 G. F. Muntz—Propelling ships
1144 F. V. Martini—Fire-arms
1145 C. E. Crighton—Steam boilers
1146 S. S. Robson—Apparatus for raising
1147 B. Tanner—Superphosphate of lime

Dated April 29th, 1871.

1148 H. Cadman—Printing machines
1149 A. S. Stocker—Bottles and stoppers
1150 S. A. Varley—Telegraph apparatus
1151 J. Walker—Blankets, &c.
1152 B. G. George—Transferring, &c.
1153 J. Murray—Double-furrow ploughs
1154 G. Greaves and W. Holroyd—Cutting tenons
1155 I. B. Harris—India-rubber hose
1156 C. W. Meiter—Cigar tubes
1157 R. and J. Miller—Paper pulp
1158 W. Thornhill—Bags
1159 J. C. Graham—Fire-arms

Dated May 1st, 1871.

1160 J. Imray—Locks, &c.
1161 T. Hydes and J. E. Bennett—Furnaces
1162 T. Hydes and J. E. Bennett—Blast engines
1163 J. Howard and E. T. Bousfield—Steam Boilers
1164 A. S. Leonard—Preparing cloth
1165 A. M. Clark—Discharging ordnance

Dated May 2nd, 1871.

1166 W. V. Baines—Window glass
1167 J. E. F. Ludeke—Motive power
1168 A. McNeile and J. Slater—Wheels
1169 E. J. C. Welch—Link motion
1170 P. K. M. Skinner—Steering ships
1171 J. Tribe—Pouches
1172 T. Truscott—Pumps
1173 W. Finley—Fire engines
1174 W. Ansell—Fire-arms
1175 R. Davis and J. Wilshaw—Mangles
1176 R. Ellis—Reversible heels
1177 F. Wicks—Beds, &c.
1178 J. H. Johnson—Lamp burners
1179 T. Schwartz—Treating wood
1180 J. G. Tongue—Cartridges

Dated May 3rd, 1871.

1181 A. M. Clark—Process of oxidising
1182 A. E. Morley, J. R. Ellis and J. G. Rollason—Lockets
1183 S. Oram—Generators
1184 F. Weldon—Compressing apparatus
1185 E. T. Hughes—Obtaining sugar
1186 J. F. Crease—Compounds for coating
1187 F. Collins—Door fastener
1188 W. White—Knapsacks
1189 J. Gamgee—Production of gold
1190 J. Wallace—Mowing machines
1191 J. Law and A. Crossley—Mules
1192 H. Starkie—Diminishing pressure
1193 H. Bird—Ornamenting
1194 F. Ball—Sorting coins
1195 W. E. Newton—Pulverising ores
1196 W. Edwards—Edge tools
1197 T. Wallen—Shearing apparatus
1198 E. Loomes—Making boxes
1199 W. M. Brown—Oscillating engines
1200 W. Peverett—Seed separator
1201 W. R. Lake—Sewing machines
1202 W. R. Lake—Windlasses

Dated May 4th, 1871.

1203 H. Stapfer and J. Sinclair—Discharging ale, &c.
1204 J. Hopkinson—Elevating apparatus
1205 H. Fisher—Stationary wardrobes
1206 J. Rowe—Flour
1207 W. R Lake—Draught tubes, &c.
1208 J. Wright—Waterproof compounds
1209 A. Turner—Carpet fabrics
1210 H. A. F. Duckham—Supply of gas
1211 A. P. Vassard—Liquid sewage

Dated May 5th, 1871.

1212 J. I. Barber—Bending metals
1213 G. H. Ellis and N. A. Aubertin—Stamping letters
1214 D. Pidgeon and W. Manwaring—Mowing machines
1215 E. H. Prentice—Phosphatic manures
1216 W. R. Lake—Substitute for hair cloth
1217 T. Haley, S. Haley, S. Haley, J. Haley and W. Paul—Embossing
1218 T. P. Baker—Drills
1219 W. Klorn—Scale beams
1220 T. Reid—Ploughs
1221 D. R. Ratcliffe—Locking apparatus
1222 J. E. Woodhouse and W. Chaffer—Machinery for clearing, &c.
1223 H. C. Ash—Railway vans
1224 M. Tildesley—Furnaces
1225 W. Francis, J. Bayley and T. Bayley—Process of tanning

Dated May 6th, 1871.

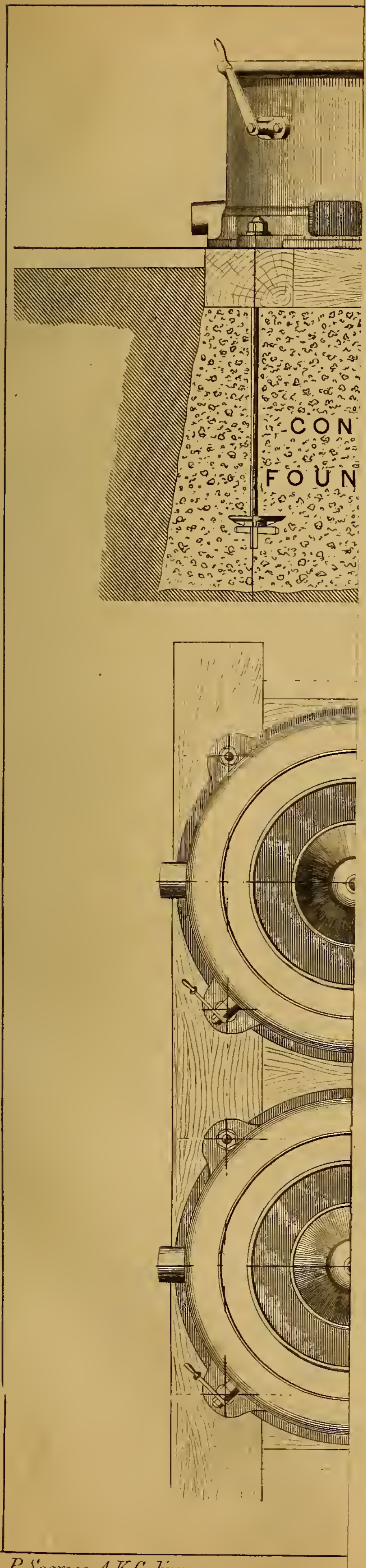
1226 J. Macintosh and W. Boggett—Treating india-rubber
1227 A. V. Newton—Liquid meters
1228 E. R. Macdonell—Dinner plates
1229 J. Oldroyd, M. Oldroyd and J. Woodcock—Stirring apparatus
1230 W. Hughes—Cooling liquids
1231 J. Bolton—Generating steam
1232 W. Garton—Saccharine material
1233 T. F. Henley—Preserving, &c.
1234 G. Oliver—Gymnastic apparatus
1235 J. Duncan and J. Stenhouse—Sugar

Dated May 8th, 1871.

1236 E. Entwistle and J. Raw—Signals
1237 E. Fairburn—Condensing wool
1238 E. G. Bartholomew—Signalling
1239 C. Lambert—Feeding apparatus
1240 H. D. Hoskold and J. E. Winspear—Surveying instruments
1241 J. Cox—Gymnastic appliances
1242 A. Anderson—India-rubber valves
1243 H. Chance—Retorts
1244 J. W. Mann and W. Parker—Mowing machines

Dated May 9th, 1871.

1245 W. Naylor—Railway breaks
1246 J. B. Fell—Narrow gauge railways
1247 G. Warsop—Pipe wrenches
1248 J. W. King—Drills
1249 H. Gardner, R. Lowe, J. Wood, J. Wood and J. Pickering—Bedsteads
1250 W. H. Garfield—Handles to teapots
1251 G. Hodgson and W. Moxon—Weaving carpets
1252 W. E. Newton—Weighing machines



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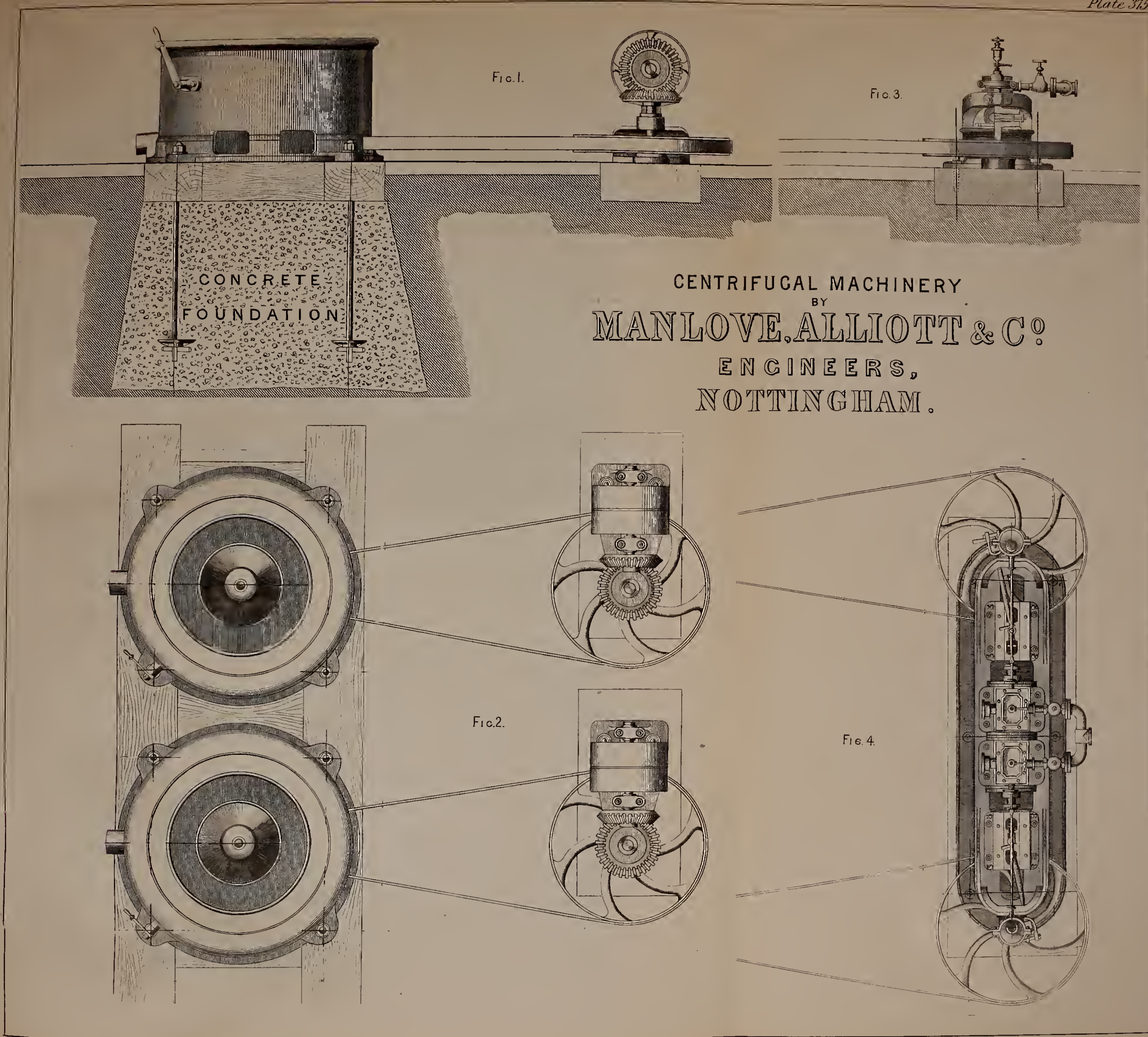

P. Soames, A.K.C. direx.

THE ARTIZAN.

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1st JULY, 1871.

THE MANUFACTURE OF CANE SUGAR IN THE COLONIES.

Centrifugal Machines.

(Illustrated by Plate 375.)

(Continued from page 99.)

Having described the principal processes at present in use for evaporating the water from the juice of sugar canes, we will now proceed to describe the various methods of "curing" the sugar; the term curing being applied to the processes adopted for separating partially or entirely the molasses or uncrystallised portion from the crystals themselves. In order to make this part of our subject more generally understood, it will perhaps be as well to define the general principles of crystallisation. When any material, such as sugar, salt, &c., is held in solution in a liquid such as water, no change will occur provided the amount of liquid be sufficient; but as soon as that amount is diminished until it is insufficient to overcome the force of cohesion between the particles of the solid, crystals are formed. These crystals are, in the case of most solids, invariably of the same shape, but differing in size; the form of a crystal of cane sugar being an oblique four-sided prism, terminated by a two-sided summit. The form, of course, is of little consequence; not so, however, the size of the crystals, as this point determines to a great extent the market value of the sugar. It has been found by experiment that, as a rule, the slower the evaporation of water the larger will be the crystals; and this fact has been extensively taken advantage of in the manufacture of sugar-candy, and also in forming the beautiful crystals of sulphate of copper, prussiate of potash, &c., frequently exhibited as ornaments in the windows of chemists.

In these cases the amount of water has been gradually lessened by evaporation, the temperature of the water always remaining the same; but in the case before us the amount of water remains practically the same, but the temperature is reduced. As, however, we have already shown, that hot water dissolves five times the amount of sugar that cold water does, it follows that the gradual cooling of a concentrated solution of hot sugar will behave in a precisely similar manner to the gradual evaporation of a cold solution. Hence, the size of the crystals formed from a "skip" of sugar will be in proportion to the time occupied in cooling, provided of course that it is not too highly concentrated to admit of the crystals forming properly.

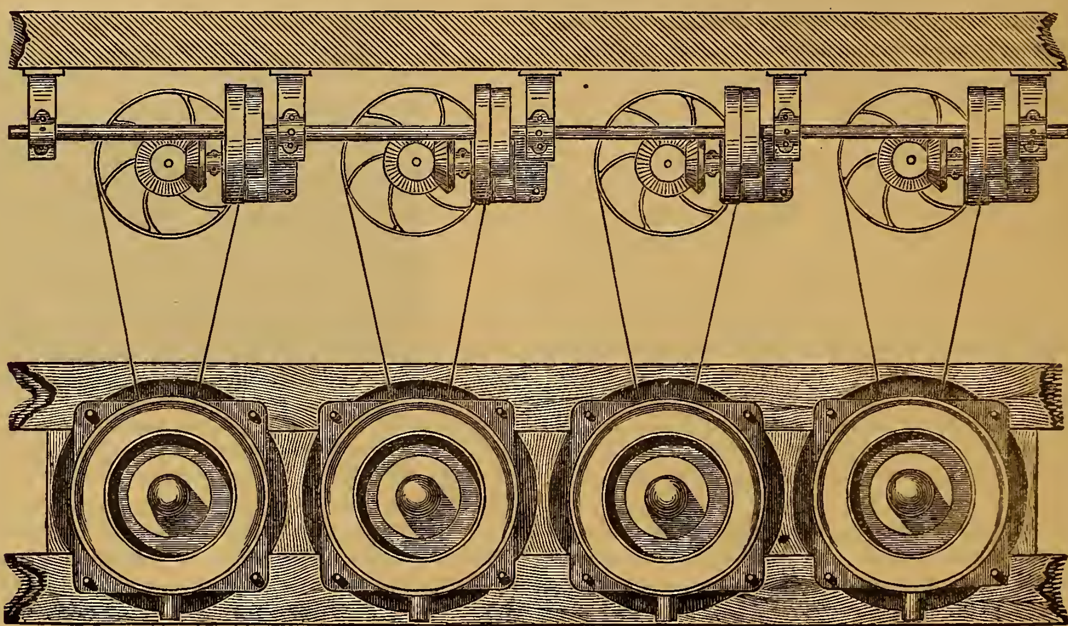
Having thus briefly stated the fundamental laws of crystallisation, we will now proceed to describe some of the more useful methods at present employed for obtaining marketable sugar. The old method, and we are afraid we must say even at the present date, the most usual method —one, in fact, that, when we first practised in the West Indies, was universal—was as follows:—

The cane-juice, after having been sufficiently evaporated over an open fire, as already described, was run into coolers of a sufficient capacity to hold two or more skips of liquor. The form of these coolers is represented in the accompanying illustration, but at that time they were constructed of wood, instead of wrought iron as here shown. The object of making these coolers large enough to hold two skips was to obtain a large-grained sugar, as it had been found from experience that when a fresh skip of hot liquor was run into a cooler containing a semi-crystallised mass, and then thoroughly stirred up, the grain was very much improved. This fact is usually accounted for by assuming that the already formed crystals act as nuclei for the crystals of the second skip; but as we have before pointed out that the size of a crystal depends, *ceteris paribus*, upon the slowness of its formation, we are inclined to consider that the improvement in the size of the grain is principally due to the retardation of the cooling consequent upon the addition of the hot liquor. When the mixture of sugar and molasses has become cold, it is dug out of the coolers, the crust on the top being thoroughly broken up and mixed with the rest of the contents, and transferred to hogsheads placed over a cistern to receive the molasses. These hogsheads have a

series of holes bored in their bottoms, into each of which is fitted a reed or rush of sufficient length to extend slightly above the top. After a few days, when the sugar—or mixture of sugar and molasses—has settled down in the hogsheads, these rushes are withdrawn, and the molasses allowed to run out through the holes. This process of draining is very tedious, and at the best most ineffectual; a large proportion—usually as much as thirty to forty per cent.—remaining in the sugar when shipped. As a natural consequence, during the voyage the hogsheads continue to drain, and the molasses mixing with the bilge water is pumped overboard. The small amount of molasses that remains when the hogsheads arrive at the market serves only to darken the sugar and depreciate its price.

The excessive loss incurred by this barbarous method of curing sugar has been long acknowledged, and numerous plans devised for separating the molasses from the sugar. The first practicable solution of this problem was, we believe, proposed by Mr. John Hague, in 1816, wherein the inventor proposed to withdraw the molasses by atmospheric pressure. In this system the uncured sugar was placed in vessels, the bottoms of which were made of perforated copper, and connected to a pipe communicating with an air-pump, by means of which the air was exhausted from the bottom, and the molasses which filled up the interstices between the crystals of sugar was sucked into the exhaust pipe. This plan, however, never found favour with the planters, chiefly, we believe, in consequence of the slowness of the process, and the cumbersomeness and expense of the arrangement requisite for performing the work even upon a moderate-sized estate. The same idea was also revived by Mr. Henry Bessemer in connection with his scheme for extracting the juice from canes by direct pressure, but, unlike his press, we are not aware that it was ever practically tried upon a sugar estate.

About twenty years ago the employment of the centrifugal machine, or, as it was then called, the hydro-extractor, which had been for some years successfully employed in drying cotton and woollen goods, was proposed for driving off the molasses from the crystallised sugar, and after a few experiments it was found to be so admirably adapted to the purpose that it rapidly found its way into most of the refineries at home and on the continent. As, however, new inventions, even when unquestionably of value, do not find favour among planters, it was some years later before centrifugal machines were tried with raw sugar. Thus, the first centrifugal machine which was forwarded to Jamaica, and which fell to our lot to erect, did not arrive until the latter part of the year 1853; and, moreover, it was about the most inferior specimen, as far as regards design, with which we are acquainted. The machine was arranged to be driven from above, and was hung on vulcanised india-rubber springs, which were erroneously supposed to prevent vibration. It was driven by a horse gear, or rather a mule gear, and, as may be easily imagined, the loss of power entailed in getting up the speed from about 2½ to 1,200 revolutions per minute, was very great. The results, however, even with this imperfect machine, decisively proved the immense advantages of curing the sugar by centrifugal force.



During the last few years the planters, who are as a rule notoriously slow to adopt improvements, have apparently realised the necessity of using them, and a large number have been manufactured for their use. As a natural consequence various designs have been proposed, having for their object the most effectual or economical attainment of the purposes for which they are intended. The various arrangements may, however, be divided into two classes, viz., those driven from above, and those driven from beneath the basket containing the sugar. A representation of a very simple method of driving a centrifugal machine, by gearing situated above the basket, is given in Plate 371, Figs. 8 and 9 (see The Artizan, March 1st, *ante*). In Fig. 8, the engine, which is attached to the outer casing of the centrifugal, drives a flat cone wheel, which is held up against a friction pinion fitted to the spindle keyed to the boss carrying the basket by means of a setting-up screw and hand-wheel. In Fig. 9 instead of an engine a strap is employed to drive the machine, and where a number of centrifugals are required this is perhaps tht most convenient and least expensive method. When these machines are at rest the setting-up screw is slack, but as soon as it is required to start the machine it is gradually tightened until the requisite number of revolutions are attained; and when it is desired to stop, this screw is again slackened, and the brake shown below the pinion is applied until the basket ceases to revolve.

In our opinion the principle of driving from beneath is far superior to the overhead system, chiefly from the fact that in the former plan the basket may be filled and emptied very much more conveniently, and partly because it is less liable to become clogged with molasses.

In order to explain the methods employed for driving centrifugal machines from beneath the basket we illustrate in the accompany Plate (375) two methods, extensively adopted, by the well-known makers, Messrs. Manlove Alliott and Co., of Nottingham. In Figs, 1 and 2 are shown a system suitable for a small sugar-house, where the upper shafting may be driven by the mill engine, by an engine which may also be employed for driving the wetzel pans, or any other machinery that may be required. In this case it will be seen that a strap connects the driving shaft with a countershaft carrying a fast and loose pulley. Upon this countershaft a bevil wheel is fitted, gearing into a pinion keyed to an upright spindle. This spindle also carries a horizontal strap pulley, the band of which passes round a small pulley keyed to the spindle of the centrifugal machine beneath the basket.

In order to start the machine the shifting gear upon the countershaft should be provided with a screw motion, so as to enable the operator to shift the belt from the loose to the fast pulley very gradually, and thereby allow the belt to slip when the machine is first started.

In Figs. 3 and 4 (Plate 375) a very convenient arrangement for a moderate-sized estate is illustrated, and one which, although each centrifugal is driven by a separate engine, the makers (Messrs. Manlove Alliott and Co.) assure us is not more expensive than the system of driving by gearing. This assertion may appear at first sight somewhat incredible, but it is no doubt correct. Thus, in either case the same steam power is required, although so far as that is concerned considerably less expense would be incurred by driving a set of centrifugals from one engine; but when we begin to calculate the cost of the shafting, pulleys, belts, &c., together with the cost of erecting in a foreign country, we are inclined to believe that the system of driving by separate engines would, if anything, be less expensive than the combined system. It will be seen that in the arrangements shown in Figs. 3 and 4 (Plate 375) that the driving engines are so arranged that the fly-wheels run horizontally, and that the centrifugal machines are driven by a strap working directly

on this fly-wheel, and the pulley on the spindle of the centrifugal. By this means no gearing whatever is required, a single strap being all that is necessary to connect the driving power with the machine; consequently the machinery works much more silently and smoothly than when gearing, at a high speed, is employed.

Upon large estates, where a considerable number of centrifugals are necessary, we consider the best plan is to drive them from a continuous shafting, such as the arrangement shown in the accompanying engraving, as in that case it is unquestionably more economical and more convenient to do so. We say more convenient, because the centrifugals can be placed closer together, which, when six or more are required, is an important item in the expense of the building; they can, moreover, be attended to by fewer skilled labourers.

(*To be Continued.*)

THE CHATHAM DOCKYARD EXTENSION.

The basin and docks opened on the 21st ult. are the largest and finest in the world. This, the first or repairing basin, opposite to Upnor Castle, has an area of 21 acres. Before full tide there was a depth of water at the entrance of 30ft.; in the basin there was a depth of 33ft. From the granite coping of the dock to the area is 39ft. The basin is 1,320ft. long by nearly 700ft. wide. The dimensions of the two completed docks are 520ft. over all in length; the width at the coping 110ft.; the two docks now in course of construction will be of the same length, but 2ft. wider; they will be completed in two years. All these docks are on the same side of the basin. There will be facilities for repairing vessels in all four docks at once, if required. The portion of the works now brought into use have been constructed under contract by Mr. Gabrielli, and he is now actively at work on Nos. 3 and 4 Docks.

The second, or Factory Basin, now being actively pushed forward, has an area of 20 acres; it is being constructed by the Government, convict labour being largely employed upon it. It is expected to be completed early next year. The third, or Fitting Basin, will be 33 acres in extent; it will be some years before it is completed, much of the site had to be reclaimed from the river. The factories have also to be erected, and a large amount of work of various kinds to be done before this immense dockyard is completed; but the portion now brought into use must prove very advantageous to the Navy.

The opening of one of the new basins at Chatham Dockyard is one of the most important events connected with the Navy which has occurred for a long time. Our eyes have been kept so intent for years upon the progress made in the construction of ironclads and the state of naval armaments that very little attention has been given to the state of our dockyards, or the means we have of docking our fleet when necessary. Now and then notices have appeared in the papers that the "extension" works at Chatham and Portsmouth were progressing; but, beyond this, the public knew very little of what was progressing, what the extension works were, whether or not they were ever likely to be completed, or that they were undertaken with any other view than that of affording work to a large number of convicts. Now, however, that a portion of these works is really complete, it will not be difficult to appreciate their vast importance to the Navy, and it may be interesting to give our readers some definite information about them. The idea of utilising convict labour in connection with works at the dockyards was conceived in a hazy way about 15 years ago. Some works were found necessary at Chatham in 1855, when it was proposed to build a new basin with two docks, and to execute the works by means of convict labour; and, in addition to this, it was proposed to carry out some other works, in the shape of a sea wall, a new mast-house, and a mast-slip. The whole cost of these works was estimated at £160,000. That this work was not supposed to be important, and was undertaken with a very loose idea of its importance, is evident from the fact that convict labour was employed exclusively upon it, and that, although the House of Commons voted sums of money every year for it, the expenditure by the end of the year 1858, hardly exceeded £10,000. In the next two or three years, when more progress was made, it was perceived that the works at Chatham were of great importance, and that their vigorous prosecution was worth consideration. In the first place, not only were steam frigates of an unusually large size being built, but a new class of vessels altogether, in the shape of ironclads, was found indispensable to the Navy; and, in the second place, it was found that our dockyard accommodation was very poor, and that, if the Government wished to retain in its own hands, to any extent, the means of building and repairing ships of war for the Royal Navy, it was absolutely necessary to possess dockyards of much larger dimensions than then existed.

Fortunately, at Chatham the means of carrying out this idea were ready to hand. It was necessary to survey the coast for new dockyards, or to consider the propriety of buying up any private yards; for adjoining Chatham Dockyard, and only separated from it by a little creek, was a large marsh called St. Mary's Island, which was then comparatively useless, and not costly to acquire. So it was determined to add this marsh, which was generally under water, to the existing dockyard, and very vigorous steps were taken by the Admiralty to carry out this intention. At the cost of £80 an acre, 150 acres were purchased and rapidly reclaimed; and designs were immediately prepared for extending the dockyard on this site upon a grand scale. Convict work by itself was found to be useless; for, while it was easily available for work of no importance, either in regard to time or to class, it could not be relied upon in such delicate and difficult work as laying the foundation of a sea wall, or converting a swamp into a dry dock. For instance, the work of laying the foundations had to be executed at low tide, and could not be proceeded with at any other time; and as convicts were compelled necessarily to conform to certain rules, it was impossible for them, as a rule, to work through a whole low tide. Then, again, much of the work was of a character requiring great skill and promptitude, which convicts do not possess.

So the original scheme was revised, added to, and incorporated with an altogether new plan, in 1862. This provided not only for the new repairing basin and its four docks, but for two other larger basins with accompanying docks, one for factory purposes where engine and machine work would be conducted, and the other for "fitting-out" purposes, or preparing ships, which had been recently launched for sea. Since 1862 these works, which form the Chatham "Extension" works, have been in progress, and the first, or "repairing" basin is now complete; but the second, or "factory" basin, is not in a very forward state; while the last, or "fitting out" basin, is decidedly in a backward condition. The total estimate for these works, which commenced in 1855 with the modest suggestion of £160,000, reached nearly £950,000 in 1862, was revised in 1865, in consequence of the necessity of adopting contract work to a larger extent, and estimated at £1,250,000, and was increased by £450,000 two years ago, and thus raised to the sum of £1,700,000.

Satisfactory as it is to know that this estimate will not in all probability, be exceeded, it is more satisfactory to know that the work is worth the money. In the navy there has been too much cause for the reproach that money voted for many branches of the service has been either squandered or has not produced satisfactory results; but, in the construction of the Chatham works, the country obtains the fullest value for its money. The basin which is now completed and ready for use may be compared, both in size and in usefulness, with any docks in the country; and the whole of the works, of which it is a part, are not surpassed in design or in the difficulties which have been overcome by the vast docks at Cherbourg. To give an idea of the extent of these works it need only be mentioned that while the present dockyard at Chatham covers 90 acres, they extend over 380 acres, so that the extension of the dockyard is more than four times as large as the yard itself. The repairing basin, which is complete, has an area of 21 acres, and a frontage of 3,000ft. In connection with it are four docks, each large enough to hold any vessel not larger than the *Great Eastern*, and varying in length from 430ft. to 468ft. The width, from the entrance, varies from 80ft. to 108ft., and the depth is sufficient to give an entrance to 33ft. of water at spring, and 30ft. at neap tides. The entrance faces Upnor Castle and is, therefore, easily accessible to shipping. These figures and statistics, unpalatable to read, are useful in affording a correct idea of the enormous mass of work which this basin and its accompanying dry docks, which are complete, represent. Acres of brickwork, varied, strengthened, or faced by granite; acres of marshy ground reclaimed from the river, and fashioned into dry docks, compose the work of the past 10 years. The difficulties have been enormous. Pleasant and unpleasant discoveries have varied the monotony of the work; for while a good bottom of solid gravel was found in one part, in another the ground or bed of the river proved unstable and dangerous. Then when it was thought that the earth which was excavated might be utilised for brickmaking, it was disheartening to discover that this earth was "patchy" and only to be met with in certain places. Again, it was necessary, on one occasion, to pull down, altogether, some of the work and rebuild it, in order to obtain a more secure foundation. So, with some successes and many disappointments, Colonel Clarke, who has devoted himself, as the director of works at the Admiralty, to the task of effecting these "extensions," is at last rewarded by seeing one portion of his work complete.

The difficulties of a gigantic undertaking like this can only be realised by actual inspection. Chatham Dockyard, with its well-paved roads, and the trim houses of the officials on one side, and the slips and docks on the other, is very different from the scene which lies on the other side of the boundary wall which separates the old yard from the "extension" works. Passing through a small door one enters upon an almost chaotic

scene. On every side one is confronted with trenches, mounds of earth, excavations, half-formed docks, sheds, and gigantic piles of granite carved in various forms to suit the docks of which they are to form the basis. These piles of ganite are, perhaps, the most remarkable evidence of the difficulties which have to be encountered and the ingenuity necessary to overcome them. One wonders how these masses of stone will find their way correctly to their destined places: and how it has been possible to form the curves, steps, and sides of docks which have not even been excavated; or how, when they have been carved, it is possible, by any system of numbering, for the separate blocks to find their way to their proper places. Yet the granite slabs which form these docks are carved years, perhaps, before they are laid down, and the wonderful precision of the work is apparent upon inspecting the beautiful finish of the workmanship in the "repairing" basin and docks which are now completed. Here, indeed, the works have an orderly appearance; but elsewhere, over the acres of excavation and rubbish which surround these new docks on all sides, it is not easy to understand how the same order is to be introduced, though it is not difficult to appreciate the ability and the painstaking perseverance necessary to carry out the plans as well as to prepare them.

It is intended to connect the three basins with one another, so that vessels can pass from one to the other without difficulty. Large factories are also to be constructed, with every class of workshop and every appliance necessary for the repair and construction of all kinds of vessels. When completed, a fleet may find refuge in these docks, and no vessel will be excluded, from the largest ironclad we possess to the smallest gunboat. As it is, the instalment which is now given to us is of no ordinary value. The energy which has been shown in completing this work, and the manner in which not only the work has been finished, but in which the constant difficulties which arise from time to time have been overcome, reflect the highest credit upon Colonel Clarke and the contractors, Messrs. Gabrielli, who constructed the new dock at Malta. An important want of the navy has been supplied, and it is hoped that the success which has attended this work may induce the Government to complete without delay the remaining works at Chatham and the corresponding extension at Portsmouth.

SUGAR FROM MELONS AS COMPARED WITH SUGAR FROM BEETS.

Mr. W. Wadsworth, in a letter to the *Sacramento Union*, maintains that sugar can be made more profitably from melons than from beets. He says:—

The sugar from cane, maple, beets, parsnips, the sweetgourd, and all the varieties of melons, when manufactured perfectly pure, are chemically identical. In Hungary and Italy there are numerous large establishments for the manufacture of melon sugars. The cost of melon sugar as compared with beet sugar is in favour of the melon. Every German or French authority on the culture of beets for sugar, admits the necessity of two, and recommends three, deep and thorough ploughings of the land to properly fit it for the culture of beets. With melons it is quite otherwise. To secure the largest yield and best beets, the seed should be planted in rows two feet apart, and from eight to ten inches apart in the row. For beets, all the land—for illustration say fifty feet in width—must be ploughed at least twice. For melons, only four beds, twelve feet apart and each only four feet wide, or sixteen feet in width of ploughed land, against fifty for beets, will need ploughing. The great expense of beet culture is in the hand-hoeing and weeding of every row, and in most lands as many as three of these weedings are required in a season, before the leaves are large and spreading enough to keep down the weeds. The difference between the weeding of four rows of melons and twenty-five rows of beets is very considerable; whilst the exhaustion of the fertility of the soil is in the same proportion. With both crops the land between the rows is kept free from weeds with the horse-hoe or cultivator, at the same expense. Young melon plants are not as tender and delicate for the first eight days as beets. It is evident, therefore, that the expense of culture is largely in favour of melons, it being less than one-third the cost of beets per acre. In gathering the two crops the difference is again in favour of melons, for they only have to be picked from the vine and thrown into carts; then, without washing or any other process, are ready for the mill. Beets must be first pulled, thrown into heaps to protect them from the sun, then each beet must be handled in having its crown of leaves and rootlets cut off, and then, before it is ready for the rasp or cutter, must be washed thoroughly clean. The gathering and handling of melons is an agreeable and cleanly operation compared with that of beets. Large quantities of melons in certain localities can be sold for direct consumption in the early part of the season, or whenever worth more in that way than for sugar, spirits, or vinegar; it is not so with beets. Sugar making can commence a full month earlier from melons than from beets, and with winter water melons, as in Hungary, continued as late as with beets. Melons yield their seed every year with no extra expense for cultivation. Beets require a second year, with land, and careful culture and gathering of the seed. Melon seeds will yield sixteen per cent of their weight of excellent table oil. Beet seeds, beyond what are needed for seed, are of no value. The oil from the surplus seeds of melon sugaries in Hungary pays one-half the cost of cultivating the entire melon crop. The yield of melons per acre, in favourable soils, is equal to that of beets. The yield of sugar is as seven per cent from melons to eight per cent from beets; but the cost of manufacture is decidedly in favour of melons; they require less time, less bone-black, less machinery, less power, and less fuel, because no water is added, which cannot be said of beet juice by the ordinary process of extraction. The natural purity of the juice of melons is so superior to that of beets, that whilst the melons furnish an agreeable "food and drink," and a delicious sweet, the juice of beets is so acrid and herbaceous to be wholly unpalatable. The defecation and refining processes for melon juice and sugar are therefore attended with far less trouble and cost. That part of the beet which in many instances grows above ground, exposed to the sun, is of little or no value for sugar, whilst the hotter the sun and the drier the air, the better and sweeter the melon. The larger the sweeter generally, whilst the reverse is true of beets. Beet juice and pulp exposed to the air, will turn black in fifteen minutes, and fermentation commences immediately from the rasp. Melon juice and pulp will not blacken at all, and will not begin to ferment in the open air before the third day from the melon. Beets are remarkable for their power of extracting alkaline and saline substances from the soil, which injures their value for sugar. Melons are equally remarkable for letting these salts entirely alone in the soil. No centrifugals or presses are required to separate the juice from the pulp, as with beets; but all except the rinds and seeds go into the defecating kettles together. Cloth filters, concentrators, and a vacuum pan are as necessary as for beets. The buildings are less costly, because requiring less strength to hold in position the centrifugals and other necessary machinery for beet sugaries. The chemical processes of melon sugar making do not differ materially from those for the making of beet sugar, except in their simplicity. Spirits in large quantities can be extracted from the fermented juice of melons and the refuse of the sugarie, and "pure cider vinegar" is made therefrom in ten hours that cannot be distinguished from the genuine article. The melon rinds, with dry grass or straw, make an excellent food for milch cows.

ON THE ESTIMATION OF MANGANESE IN SPIEGELEISEN AND FERRO-MANGANESE.

By Thomas Rowan, F.C.S.

The following process for the determination of manganese is, I need hardly say, not novel; but, having had occasion to make many estimations of manganese in spiegeleisen and ferro-manganese, I can recommend it as superior for speed and accuracy, where manganese in quantity has to be determined, to the other processes commonly resorted to. A convenient quantity of the sample, say 20 grains, in as fine a state of division as possible, is digested in a long-necked flask, with about $1\frac{1}{2}$ ozs. of hydrochloric acid, until complete solution is effected. The solution is then oxidised with chlorate of potash added from time to time, and finally boiled until traces of chlorine can no longer be detected. The solution is now saturated by liquid carbonate of soda added in small successive quantities, the flask being well agitated after each addition of the alkali. On nearing the point of saturation, each addition of the carbonate of soda occasions the separation of small quantities of carbonate of iron and manganese, which disappear on the flask being shaken. When this is observed the alkali must be added with extreme caution, but the deep blood-red colour now acquired by the solution will, after a little practice, be a sufficient indication to the operator that the desired point of saturation or neutralisation has been attained. Or, if it is preferred, the smallest excess of carbonate of soda may be added, and the permanent precipitate which forms re-dissolved by the cautious addition of hydrochloric acid, introduced drop by drop. Before treating with carbonate of soda, the solution should be evaporated to as small a bulk as possible, the presence of much free acid causing the expenditure of an unnecessary amount of alkali, and the violent effervescence caused by the escaping carbonic acid often entails loss by the projections of portions of the solution from the flask. From 6 to 8 ozs. of water are now added, and the iron precipitated as the basic acetate of iron, by the addition of a concentrated solution of acetate of soda. If the solution has previously been successfully neutralised with carbonate of soda, the ferric acetate will at once make its appearance; but if that point has not been reached, the iron will only precipitate after boiling, and then not completely, and the precipitate will be found to be so gelatinous as

to cause much trouble by clogging the filter. After the addition of the acetate of soda, the flask and contents are briskly boiled for about twenty minutes, and then allowed to repose a few minutes, that the acetate of iron may settle to the bottom of the flask, when the solution is carefully decanted from it on a filter. More water is then added to the flask, with a few drops of acetate of soda, boiled for five or six minutes, and again decanted from the precipitate. This is repeated a third time. The acetate of iron can then be thrown on the filter and washed with boiling water. The filtrate, with washings, is removed to a beaker and brought to a temperature of about 100° F., and a stream of chlorine gas passed through until a faint smell of that gas can be detected from the liquid. This is ascertained by stopping, from time to time, the passage of the chlorine, blowing from the surface of the liquid in the beaker the gas that may have lodged there, and then testing by the smell. If chlorine can be detected the addition of the gas is finally discontinued. The beaker is now carefully covered and set aside in a moderately warm place for six hours. The precipitated binoxide of manganese is removed by filtration, and chlorine is again passed through the filrate to ascertain whether all the manganese has been removed. When the precipitated manganese settles to the bottom of the beaker, if the liquid above is purple-coloured it indicates that an excess of chlorine has been used, and that permanganic acid has been formed. This is easily remedied, as the permanganic acid is at once reduced to the binoxide by the presence of any organic matter. A few drops of alcohol may be added, and the precipitated binoxide of manganese filtered off. The precipitated binoxide of manganese is re-dissolved by pouring hot dilute hydrochloric acid on the filter. The manganese is re-precipitated as carbonate by a solution of carbonate of soda, and boiled well to expel all carbonic acid, the carbonate of manganese being slightly soluble in carbonic acid. The carbonate of manganese is then collected on a filter, washed well with boiling water, dried, ignited, and weighted as the red oxide. The binoxide of manganese has such a tendency to appropriate alkali that it cannot be directly ignited to the red oxide. When this is done without re-dissolving and re-precipitating as carbonate, I have found that one part of the ignited precipitate contains 0·0842 of alkali, which must be deducted from the weight before calculating the percentage of metallic manganese. If the weight of the ignited red oxide thus obtained be 3 grains, the following calculation is made :—

Wt. of red oxide ppt.
1 : 0·0842 :: 3 : 2·7474

In a rigorous analysis, however, it will be found more satisfactory to proceed as directed above, namely, re-dissolve the binoxide of manganese first obtained, and re-precipitate as carbonate before proceeding to ignite and weigh. The amount of metallic manganese is readily ascertained from the weight of the ignited red oxide, 100 parts of which contain 72·05 parts of metallic manganese.

TRIAL TRIP OF THE "GLASGOW."

The *Glasgow*, unarmoured wood-built screw frigate, 28 guns, 3,087 tons, 600-horse power, Capt. T. M. Jones, fitted and recently commissioned for flagship duties in the East Indies, was put through her official trials of speed over the measured mile in Stokes Bay, on the 6th ult. On entering upon her speed trials the frigate, being at her own load line, drew 21ft. 1in. of water forward and 23ft. 8in. aft. The wind was from the N.E. to N., at a force of 2, and the water in Stokes Bay perfectly smooth. Six runs were made over the mile under full boiler power, and these gave speeds of 11·392, 11·842, 11·592, 11·465, 11·842, and 10·909 knots per hour, the mean speed of the ship being 11·529, knots per hour. The runs of the ship over the mile with half boiler power only gave her a mean speed of 8·578 knots per hour. Eleven and a-half knots per hour as the measure of the speed that can be attained under the most favourable conditions by one of our latest-built wooden screw frigates is only remarkable from its apparent deficiency of pace, and this apparent deficiency becomes the more striking when it is remembered that the half-boiler power speeds of our latest ironclads equal the full-boiler power speed of the *Glasgow*. The improvements introduced in the engines of our ships of war since the construction of wooden frigates of the *Glasgow* type have been abandoned, and the "short-and-handy" ironclads designed by Mr. Reed have made their advent, fully explain the cause of this superiority of speed by our modern ugly-looking ironclads over the handsome unarmoured and wood-built screw frigates. "Nominal" is a word, in fact, as applied to the power of a ship's engines and retained in use on the Admiralty official *Navy List*, delusive in its meaning, and now of no definite quantity. When the *Warrior* was built the old conditions with regard to the contract for the engines existed—*i. e.*, that they should actually exhibit on their trial a power of four times their nominal designation. When Mr. Reed's ironclads were designed and ordered to be built the contractors for their engines found themselves called upon to exact with the new engines on their trials a force of six times their nominal power. Shortness in the ship driven was thus compensated for by increased power in the engines driving them, but the objectionable "nominal" definition has been retained throughout. Simply as relating to the actual force required to drive ships of different forms and lengths, but having the same so-called nominal power of engines, we may refer to the earliest and the latest constructed of our ironclads—the *Warrior* and the *Sultan*. The latter ship's engines on her speed trials indicated a force about double that indicated by the *Warrior's* engine on her speed trials, and yet the speed of both ships under these remarkably dissimilar conditions proved to be as nearly as possible equal. Roughly speaking, while the *Warrior* required a force of 5,000 horse to drive her $14\frac{1}{2}$ knots, the *Sultan* required 10,000 horse to drive her at the same rate.

MERCHANT SHIPPING CODE.

The following is a memorandum prepared by the Honorary Secretary of the Institution of Naval Architects, on his own responsibility, and forwarded by him to the Board of Trade, with the permission of the Council :—

In the instructions given to the sub-committee appointed to consider the Merchant Shipping Code on behalf of the Institution, you were careful to confine the action of the committee to those points which directly affected the interests of the naval architect and shipbuilder, and the sub-committee have also been careful not to exceed those instructions. There are, however, points of importance to the public, and to gentlemen connected with the shipping interests, to some of which I hope you will excuse my calling your attention on my own responsibility.

1.—One of the most important of these is the new definition of "passenger" and "emigrant" ships in section 293 (p. 127).

It seems to me that a large number of vessels carrying first-class traffic only, such as the Cunard Line, West India mail, African mail, and so forth, will fall somewhat unnecessarily under the control of the Emigration Commissioners.

2.—A passenger steamer also is defined as any British steamship carrying passengers, and the term *passenger* is defined to mean any person carried for hire in any ship.

It appears to me that some relaxation ought to be made in the direction of permitting a small number of passengers to be carried in cargo steamers, trading foreign, without subjecting the owners to the extra cost of fitting the ship as a regular passenger vessel. There are many small ports which are only occasionally visited by ships, and these of course exclusively small cargo ships. Now, I do not think it desirable that a person should be absolutely shut off from the possibility of getting a passage in such a ship, because it is not worth the owner's while to register her as a passenger ship. By sailing vessels there has been hitherto no bar to this; but screw steamers are rapidly taking their place, and if a single passenger is to make a passenger steamer, many small ports will be absolutely cut off from the rest of the world, and, *à fortiori*, from direct passage from one to the other. Too sweeping legislation is quite as dangerous as want of control, and the cases for exception are to be judged quite as much by their individual importance as by their frequency.

I think a limiting clause should be introduced, authorising a small number of passengers to be carried in cargo ships, either without any supervision, or with some *cheap* certificate that there is accommodation and food sufficient for the voyage. I might be glad of a passage in a whaler, which could hardly be expected to qualify as a passenger ship. As a substantive proposal, I would suggest a clause limiting the number to ten passengers in a steamship over 500 gross register tons, or in any sailing ship ; or to five passengers in smaller steamships, as not bringing them within the regulations affecting passenger vessels.

It may be worth while to recal to mind that the recent tendency of excise legislation with reference to inland conveyance has been in the direction here proposed. There is no longer any restriction on the carriage of passengers for hire in conveyances drawn by horses, except in the case of hackney or stage coaches plying for hire in public streets.

3.—Section 201. I think the absolute limitation of the compensation to a seaman for bad provisions, or the want of anti-scorbutics, to a shilling a day is bad in principle. There ought to be a reservation of the general right to substantial damages where a substantial injury is thus inflicted. Again, in section 210, I think the failing to comply with an order made by a magistrate, &c., ought to be visited with something more than a fine. It is a case for committal. I think also that section 210 should be made to run on all-fours with section 234.

4.—I think simple desertion, or refusal to join a ship, in a safe port, should be looked upon as a mere breach of contract involving a lien upon wages and clothes, but not imprisonment as a penal measure. I am

quite aware of the difficulties and objections attending this; but I believe nothing short of it will stop the vicious system of advances upon which "crimping" depends, and oblige owners to foster the good character of seamen by leaving them nothing but that and good treatment (beyond the civil process) to depeud upon as their means of retaining them. My domestic servant, deserting me snddenly, whatever may be her legal liability, practically eseapes by sacrificing part of her wages, and my certificate as to her good character. No healthy trade can work upon compulsion, and I believe that this is the first indispensable step to bringing about a proper relation between owners and seamen. I do not think, if the criminal treatment of desertion (otherwise than ship in danger) were done away with, there would be any need for insisting on anti-scorbutics or comfortable vessels.

5.—BOARD OF TRADE INQUIRY. I think the Court instituted in section 450 ought to have and to exercise the power, whenever it appears that any person is likely to be criminally liable iu case of a shipping easualty, of ordering him into safe custody, and of taking or refusing bail.

In a recent ease of collision between the *Corlic* and the *Desire* of Penzance, the latter vessel going down with a loss of seven lives, the Court found the master and mate of the *Corlic* guilty of negligence, and suspended their certificate for twelve months; but we do not read that either of them stood committed for murder or manslaughter. It is to be remembered that as no bodies were picked up there could be no coroner's inquest.

6.—By section 459, in case of wreck, the list of officers who may take command is rather curiously arranged. An officer of inland reveuue, who may be a mere exciseman, takes precedence of a sheriff, a magistrate, or a naval officer. This certainly wants re-arranging.

7.—While I have ventured upon these criticisms both of principle and detail, I eutertain no donbt that this proposed code is a marked improvement on the existing state of things. My impression on the whole, however, remains, that there is too much of specific and detailed regulation, with limited penalties—too much inspecting, surveying, and giving certificates on cursory survey.

A good beginning of reducing this will be made if the suggestion of your sub-committee,* to consolidate the surveys, as regards safety of ship, now separately made by the surveyors of the Board of Trade and the Emigration Commissioners, should be adopted. But therc still remain iu many cases separate surveys, not only for Lloyd's or the Liverpool Board, or other underwriters' associations, bnt also by a surveyor of mail ships—by a snrveyor of troop ships—by a surveyor of store ships; and it is quite possible that surveys by five different Government officers may have to be made for one ship ou a single voyage.

I cannot help thinking that it would be better to substitute broad general principles of safety, health, and propriety, for mnch of this Procrustean detail. I say *Procrustean* advisedly, for any great change either in the strncture, propulsion, or navigation of ships, or in onr social habits, wonld make it a misfit at once. It is, clerically speaking, easier to modify a code of detailed rules than to lay down and legislate upon any more general basis. There are innumerable reasons why public departments will endeavour to follow the easier course, and there is every reasen why they should not be allowcd to do so.

CHARLES W. MERRIFIELD, Hon. Sec.

9, Adelphi-terrace, W.C., May, 1871.

The following letter has been addressed by the President of the Institution of Naval Architects to the President of the Board of Trade:—

Institution of Naval Architeets, 6th June, 1871.

Sir,—I am reqnested to inform you, that in compliance with a resolution passed at the annnal general meeting of this Institution, the Council havo earefully considered the proposed Merchant Shipping Code, and have decided to recommend the following changes:—

REGISTRY ACT.

That there be iuserted in the second schednle at the end of line 6, p. 33, the words—" (with plans or drawings drawn to scale), of the construction load water-line of the ship, her scale of displaccment from light to load water-line, a vertical longitudiual section showing the watertight compartmcnts (if any) aud the capacity of each in cnbic fcet, a vertical cross-midship section showing the extreme draught to which hc cousiders she can be laden with safety." Further, that this ccrtificate should be in duplicate.

The clauso will thus read as follows:—" (1.) In tho case of a British-bnilt ship, a certificato (which the builder is hereby required to grant in duplicatc under his hand), coutaining a truo acconnt (with plans or drawings drawn to scale) of the construction load water-line of the ship, her scale of displacemcut from light to load water-line, a vertical longitudinal section showing tho watertight compartmeuts (if any), and the capacity of each in cubic feet, a vertical cross-midship section showing the extreme draught to which he considers she can be ladeu with safety, and also containing a true account of the proper denomination and of the tonnage of the ship, as estimated by him, and of the time when and of the place where she was built, and of the name of the person (if any), on whose account he built the same, and if there has been any sale, the bill of sale under which the ship, or a share therein, has become vested in the applicant for registry."

That the words "the builder's certificate and plans" be inserted in the list of the documents to form part of the registry and of the ship's papers. That the following alterations also be made:—p. 3, line 25, after the word *registrar* insert "the builder's certificate (in dnplicate) and plans and;" p. 4, liue 24, instead of *the builder's certificate* insert "one copy of the builder's certificate and plans;" p. 5, line 40, after the word *her*, insert "including one copy of the builder's certificate and plans;" p. 25, line 2, after the word *registry*, insert "including the builder's certificate and plans;" p. 33, line 24, after the words *in the*, insert "builder's certificate and in the."

MASTERS AND SEAMEN ACT.

That on p. 110, line 7, after the word *registry*, there be inserted the words "inclnding the builder's certificate and plans."

PASSENGERS' ACT.

That after elause (1) of the schedule, p. 164, line 21, there be inserted "(1*a*.) In iron ships built snbsequent to the passing of this Act: As to compartments separated by watertight partitions, whether they are sufficient in number, strength, and otherwise, for the ship when laden to float safely, even if one compartmeut were filled with water, or placed in free communication with the sea."

PREVENTION OF ACCIDENTS ACT.

That in section 409, clause 3, p. 179, line 33, the followiug words be added:—"By adjusters of compasses duly certified by the Board of Trade, after examination, as properly qualified."

That in section 412, the words "by reason of the defective condition of the hull," p. 181, line 7, and the words "hull of such" and "of repair," in line 10, be omitted.

These amendments will make several changes of detail necessary, in order to adopt the remaindre of the Bill to suit them; but the Council are of opinion that this is a matter of detail, which is best left to the draughtsman in charge of the Bill.

I have also the honour to forward to you the copy of a paper, read before the general meetiug by Mr. Thomas Brassey, M.P., "Upou the Examination of Adjusters of Compasses." The Council are strougly of opinion, it being conceded that the adjustment of compasses in iron ships is indispensable, that it is also necessary that proper measures should be taken to test the competency of the persons employed to adjust them, and to certify that they are duly adjusted.

I have the houour to be, Sir,
Your obedient servant,
(Signed) JOHN S. PACKINGTON, President.

The Right Hon. Chichester S. Fortesque, M.P., &c.

THE PACIFIC RAILWAY (U.S.) AND THE CHINA TRADE.

The tea-trade of the United States is being rapidly revolutionized as the result of the opening of the Pacific Railroad, that routo having proved both the cheapest and most expeditious. The lowcst rate from Yokohama to New York, including insurance and all other charges, as well as freight, is $5\frac{1}{4}$ cents a pound. The total rates from Yokohama to Chicago, by rail from San Francisco, are now $4\frac{1}{2}$ ceuts. The difference in time is between forty days by rail to Chicago, and one hundred and twenty days by the Snez route to New York. As the rcsult of this superiority of the continental route, many leading Chicago houses have established direct ageucies in Japan, and within two mouths, according to the Chicago *Tribune*, twenty-five thousand ehests, of about sixty pounds to the chest, have come by rail, to that city direct for the Westeru trade; and about fifty thousaud chests have passed throught Chicago to New York and other Eastern points. The *Tribune* adds exultiugly:—"We have thus imported at lcast 200,000 dols. worth of tea direct for our own use, aud twicc as much more has passed through here to Eastern markets. This shows that, at existing rates, Chicago importers of tea can compete with the New York sea-brought tea itself, aud save two-thirds of the iuterest on the capital required to do the New York business. In short, the occan route for tea is as surely a thing of the past as the eamel routc thorough the deserts of Arabia was snperseded when De Gama sailed around the Cape of Good Hope to India. Ocean transportation cannot cudure long wheu, in additiou to the saving of time, and hence, of iuterest on capital, the actual freights are made lower by the quick land route. More thau half the Chicago tea importers are now buying, or havo begun their arrangemcnts to bny, direct from Yokohama, aud tho New York importers arc unanimously turning to the new and quick routo."

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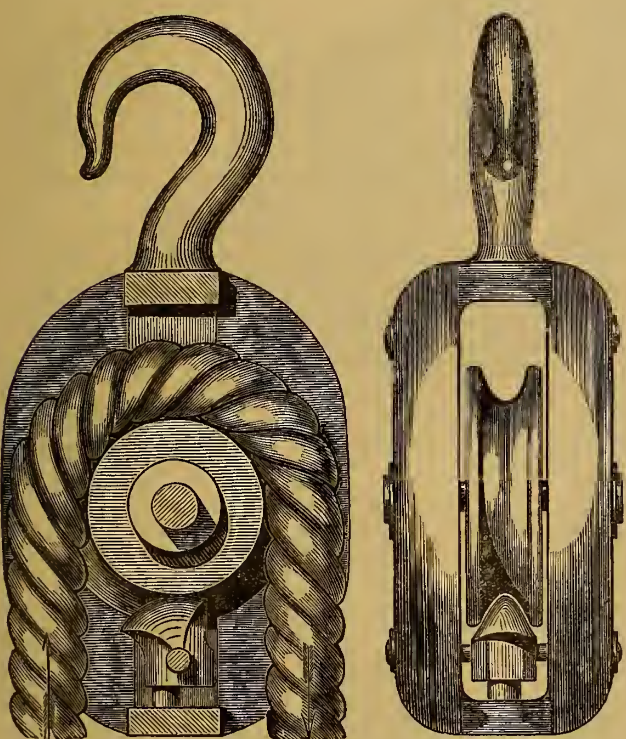
* This suggestion of the sub-committee was not confirmed by the Council.

IMPROVED SHIPS' BLOCKS AND GIPSY WINCH.

Designed and constructed by Mr. Arthur Paget, Engineer, Longhborough.

The accompanying engravings show a side and front elevation of one of Mr. Paget's improved blocks, which are at present on view at the International Exhibition. It will be noticed that at the lower end of the block there is a tumbler, which produces a similar result to that obtained by the application of a pall, for though it allows the sheave to revolve freely in one direction it will not allow it to revolve in a contrary direction, as upon the sheave turning so as to act upon the round portion of the tumbler, the latter becomes wedged in the groove of the sheave, and so jams it and prevents its revolving, and again on the sheave changing the direction of motion the tumbler relieves itself, leaving the sheave free to revolve. The tumbler is kept in position by a small india-rubber spring.



The practical utility of the invention is shown by the experiments described below. On account of the sheaves only being able to revolve in one direction, a rope being hauled in can only be overhauled by the rope slipping over the sheave, and the first experiments were made with the views of ascertaining the holding power of the tumbler arrangement and the force requisite to cause slipping.

A 2¼in. ships' black rope was rove through a 7in. block, the groove in the sheave of which had sides, enclosing an angle of 40°, and a load of 1 cwt. was attached to one end of this rope. This load when raised was found to be held steadily by a load of 12lbs. at the other end of the rope. These weights being removed, an experiment was made to ascertain what weight was required to overhaul the rope, or cause it to slip over the sheave when held still, and 15lbs. was found to be sufficient.

The objection may be raised that the friction of the rope slipping over the pulley, will be very detrimental as causing much wear, but when it is considered that the usual practice in lowering a weight, is to take the rope a turn round a cleat or belaying pin, to get the necessary frictional resistance, it becomes evident that the wear in slipping over the sheave must be much less than that in slipping over the belaying pin.

In the next set of experiments a 2¼in. white rope in ordinary condition, was tried with one of Mr. Pagets 5in. blocks, having a sheave with a semi-circular groove, under these conditions the load of 112lbs. was held by a weight of 66lbs. at the other end of the rope, and the weights having been removed, the rope was overhauled by a weight of 3lbs. only. Showing the holding power of this form of sheave to be far inferior to that of the former.

In some instances when a rope has been got tolerably taut by the ordinary means, it is swayed, that is to say, the free end of the rope is taken one or two turns round a belaying pin, and held by one man, whilst another sways or drags the rope sideways, and upon his letting it go again, as much as possible of the slack is taken up round the belaying pin, and thus the rope is got yet more taut. Experiments were tried to show the proportion of the strain thrown upon the rope, and that which can be retained both by the ordinary method and when using Mr. Pagets blocks.

In the first trial a 2¼in. rope was rove through an ordinary block aloft, and one end was attached to a spring dynamometer, and the other end was taken in round a common belaying pin in the usual way. Under these circumstances a permanent strain of but 1 cwt. could be got on the rope, although the index of the dynamometer showed a maximum strain of 5 cwt., therefore the maximum and effective strains were as 5 to 1.

The rope was then passed through one of Mr. Pagets blocks, and under similar circumstances the strain was 5⅜ cwt., and of this 3 cwt. was held as a permanent strain, the ratio being as 43 to 24.

In the next experiment the rope still taken through Mr. Paget's block aloft, instead of passing direct to the belaying pin, was taken through a second block below, and then made fast to one of Mr. Paget's cleats, the the free end being taken in by the second man as before. With this arrangement the maximum strain produced by swaying was 6¼ cwt., and the permanent strain taken in 4¼ cwt., the ratio being 25 to 17.

Finally the arrangements last described were again tried, but one man only was engaged to both sway the rope and take in, the maximum strain was 3½ cwt., and the permanent strain 2½ cwt.

It is interesting especially to compare the first experiment on swaying with the last. We find in the former case two men employed, put a tearing strain on the rope amounting to 5 cwt., but all the permanent or useful strain obtained was 1 cwt., whereas in the last experiment where Mr. Pagets improved blocks were used, a useful strain of 2½ cwt. was obtained, and the maximum destroying strain was only 3½ cwt., while the work was done by one man instead of two. These facts speak for themselves, and nothing we could say would render them more strikingly illustrative of the great advantages obtained by the use of Mr. Paget's patent blocks.

We will now pass on from the consideration of the winch, and describe Mr. Paget's winch.

In the accompanying engravings, Figs. 1, 2, and 3, for which we are indebted to *Engineering*, show respectively a perspective view, a longitudinal section and a transverse section of Mr. Pagets improved gipsy winch, but before proceeding minutely to explain its construction it seems desirable to make a few observations on the form and application of this kind of apparatus, as ordinarily arranged, to the end that the advantages of Mr. Pagets improvements may be more readily understood and appreciated.

The barrel of the common gipsy winch is of the same form as that shown at Fig. 1 in general contour, but at its greatest diameter, instead of the ratchet wheel there is an ordinary spur wheel, into which gears a small pinion fastened on a shaft, carry a winch handle so that the mode of increasing the force applied is identical with that adopted in the common single purchase crab. The gipsy winch is thus used; the free end of the rope required to be hauled is passed two or three times round the barrel, and as the hauling proceeds, the free end coming off the barrel is taken up and kept taut to prevent the coils on the barrel from becoming sufficiently loose to slip. The object of tapering the barrel is to cause the rope being hauled to keep about a constant position, otherwise it would follow on and probably ride on to the gearing. Now, it will be observed, in such an arrangement, there is no means of varying the power of the winch, because the gearing and the length of the winch handle are constant, hence the power must be so proportioned as to meet the maximum strain required to be exerted, which is arrived at when the rope has become sufficiently taut, as the strain may be said to commence at *nil*, when the first slack is beginning to be hauled in. The result is that the rate of hauling is as slow under the light strain as under the heavier one, so long as the motive force continues constant in its velocity and in turning a winch handle, however light the strain, the velocity at which a man can move his hand is soon reached, hence it is evident that with the ordinary gipsy winch there is much loss of time at the commencement of hauling.

We will now describe the means by which Mr. Paget obviates this inconvenience, and in other respects renders this winch far more efficient than the common ones. At the larger extremity of the winch, there is an ordinary ratchet wheel and pall to hold the barrel, while the actuating power is temporarily suspended, and at the smaller is a disc fitted with palls taking into an internal ratchet wheel in the narrow end of the winch barrel, the outer surface of the disc carries two eyes in which the winch handle is held. The principle features in the arrangement are

the adjustability of the winch handle and the combination of the two ratchet wheels, of which the outer one with its pall is seen in Fig. 1 and also in section at Fig. 2, in which is also seen the internal rack and palls, the front view of the palls being shown in Fig. 3.

Let us first consider the arrangement of the winch handle. It will be observed from the illustration, that it admits of adjustment as to length so that it may be effective 10in., 15in., or 20in. long. In commencing to haul, the handle being set at 10in., the barrel may be caused to revolve more rapidly in taking up slack until the leverage is found insufficient to overcome the increasing strain, when the length of the handle may be increased to 15in., and subsequently if required to 20in. During the time that the length of the handle is being adjusted, as a matter of course the pall acting on the large ratchet wheel holds the barrel, and prevents the strain from turning it back again.

framing consisting of two uprights reaching the roof of the gallery with cross beams at top and bottom, the bottom beam being about 2ft. 6in. from the floor. The top beam carries blocks and the bottom the gipsy winch, and some of Mr. Pagets patent cleats, &c. The diameter of the barrel at the smallest end was 4⅝in. In the first experiments a 3in. white rope was passed through an ordinary block, one end being brought down for the attachment of weights to be raised, and the other brought down to the winch. The following results were obtained:—

With the winch handle at 10in. radius the weight raised was 1¼ cwt.
" " 15in. " " 2¼ "
" " 20in. " " 3 "
" " 20in. " but worked with the vibratory or "pumping" action 15 "

It is noticeable that the increased force produced by increasing the

FIG. 1.

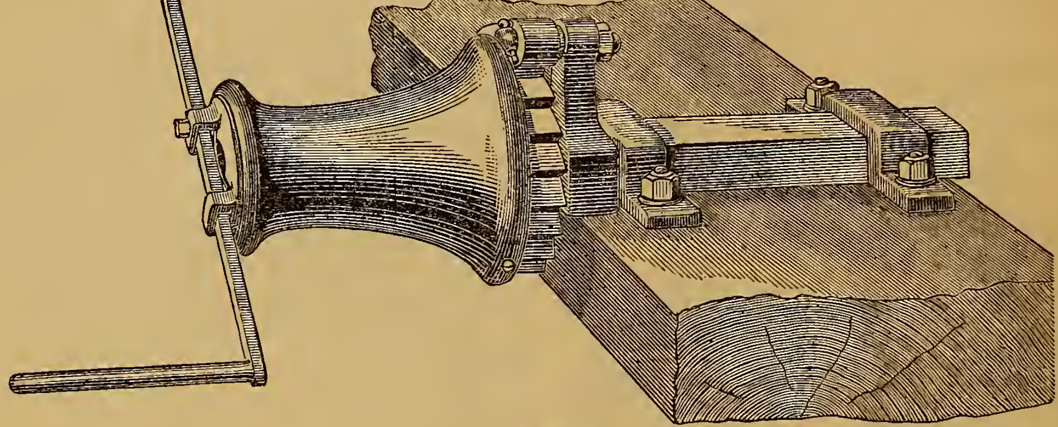


FIG. 2.

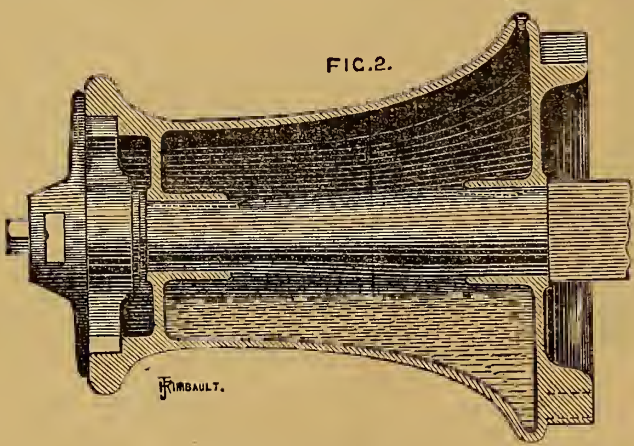
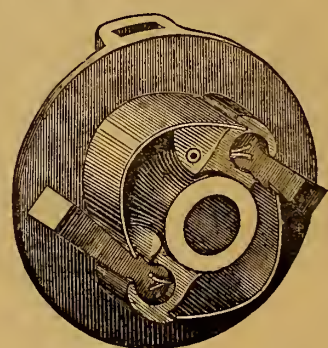


FIG. 3.



The combination of the two ratchets, however, is the most noticeable as affording a striking means of obtaining a very remarkable increase of power as it enable the barrel to be worked by imparting a vibrating movement to the handle, that is to say the man working the machine, can pull the handle up to a convenient position and then by means of the internal ratchet lower it again so as to get another pull, the large ratchet holding the barrel in the mean time, the mode of action appearing similar to the common way of working a ratchet brace. The great advantage obtained, thus is evident, as a man exerts a much greater force in pulling a lever up as described, than in the ordinary way of turning a winch handle. In fact it has been proved that five times the strain can be thus obtained. Also if further leverage is required, a lever can readily be fitted on to the end of the handle. These remarks show that in general arrangement of his gipsy winch, Mr. Paget has obviated the defects, which hitherto so materially detracted from the utility of that class of nautical apparatus, and the experiments tried at the International Exhibition and detailed below, give ample proof of the practical value of his invention. We may here mention, that in the interior of the barrel is a supply of oil for purposes of lubrication, but we believe that Mr. Paget does not claim this as a part of his invention.

In the exhibition, Mr. Paget's apparatus is carried on stout timber

radius of the handle, increases in greater ratio than the length of the handle, which is probably due to the lower levers being more convenient to work, and the last experiment proves the assertion made above, that the vibratory movement enables a man to exert a maximum pull five times as great as he can with the rotary movement, as the drum of the winch is held stationary by the ratchet, while the handle is lowered, and the whole lifting force of the operator is made available.

THE MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the Executive Committee of this association was held at the Offices, 41, Corporation-street, Manchester, on Tuesday, May 30th, 1871, Hugh Mason, Esq., Vice-President, Ashton-under-Lyne, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, which on that occasion was for two months, and is given in abstract as follows:—" During the past two months 413 visits of inspection were made, and 884 boilers examined, 483 externally, 22 internally, 9 in the flues, and 370 entirely, while in addition 22 boilers

were tested by hydraulic pressure. Two of these hydranlic tests were ordinary ones, simply to ascertain the snfficiency of boilers already in work, while in the other 20 cases the boilers were new ones, and were tested by hydraulic pressure, as well as specially examined, both as regards their construction and complement of fittings, before leaving the makers' yard. In the 884 boilers examined, 173 defects were discovered, 12 of them being dangerous. Furnaces out of shape, 2—1 dangerous; fractures, 39—3 dangerous; blistered plates, 15—1 dangerous; internal corrosion, 35; external ditto, 19—3 dangerous; internal grooving, 29—external ditto, 3; feed apparatns out of order, 1; water ganges ditto, 3—1 dangerous; blow-ont apparatus ditto, 3; fusible plugs ditto, 1; safety-valves ditto, 3—1 dangerous; pressure gauges ditto, 7; boilers without safety-valves 1; without pressure gauges, 1; without blow-out apparatus, 2; without feed back pressure valves, 7; cases of deficiency of water 2—dangerous.

"Explosions.

"On the present occasion I have five explosions to report, by which six persons were killed and five others injured. In four of these cases the scene of the catastrophe has been visited by an officer of this association, while in the fifth, which occurred in the South of England, particulars are being obtained by a resident in the locality. Not one of the boilers from which these explosions sprnng was under the inspection of this association. Before entering on the consideration of the above, the particulars of a prior explosion, ranking as No. 14, may be given, detailed reference to which had to be deferred in the last report:—

"A Boiler reduced by External Corrosion to the thickness of a Sheet of Brown Paper.

"No. 14 explosion, by which two persons were killed, occnrred at about half-past seven o'clock on the morning of Thursday, March 23rd, at an iron foundry. The boiler was a small one of the Cornish type, having a single furnace tube running through it from end to end. Its length was 7ft. 3in.; its diameter 3ft. 3in. in the shell, and 1ft. 10in. in the furnace tnbe, while the thickness of the plates was a quarter of an inch, and the steam pressure 35lb. per square inch as nearly as could be ascertained. The boiler failed in the furnace tube, the belt of plating nearest to the back end rending longitndinally close to a seam of rivets at the crown, and then folding inwards. In this way an opening about 2ft. square was formed, through which a torrent of steam and hot water issued, blowing up the greater portion of the brickwork seating, raising to the ground the chimney, as well as a part of the boiler-housc, and also carrying away the fire bridge, fire grate, and furnace mouthpiece, which it discharged into the moulding shop like a shower of grape shot, thereby so seriously injuring the nephew of the owner, who was the manager of the works, and another yonng man standing near him, that they both died shortly after. The cause of this catastrophe, as in previous instances, was extremely simple. The boiler, though laid down some ten years since, had never been examined either in the furnace tube or external flnes. Meanwhile corrosion had been stealthily attacking the boiler externally, and undermining its strength. The plates in the brickwork flues were found to be so wasted in places that they could be indented with a heavy blow from a hand hammer. In the furnace tube the crown was seriously redneed throughont, some of the plates being not more than $\frac{1}{8}$ of an inch in thickness, and others $\frac{1}{16}$th; while, jnst where the rent occurred, the plate was no thicker than a sheet of brown paper. Competent inspection could not have failed to have detected the corroded state of this boiler in time to have prevented the explosion, and saved the lives sacrificed thereby. It may be pointed out that this is the third explosion that has occurred this year at the works of engineers or ironfounders, while the manager of the works, who was killed, attended the boiler himself. It would be supposed that boilers at snch establishments would receive more competent attention than in the generality of cases, and that examinations would be made by the parties themselves. It appears, however, that this view is not borne out in practice, and that it is as necessary to put some pressure upon the owners and managers of this class of works, as upon other people, to induce them to adopt inspection, and to prevent their sacrificing their own lives and property. At the inquest the witnesses called were those employed at the works. No light was thrown on the cause of the explosion, and the jnry brought in the usual verdict of 'accidental death.' It is reported that the coroner had received a requisition from the Government for information on the subject of steam boiler explosions, with the view, it was supposed, of legislation thereon. The mode in which this inquest appears to have been conducted, and the result arrived at, clearly shows the necessity there is for some legislative interference on the subject. Such an inquiry, which is only one of a great number, practically amounts to an instrument whereby a steam user who has killed several of his fellow-creatures by working a bad boiler, may be whitewashed from all blame, absolved from all responsibility, and receive, as it were, a *carte blanche* to lay down an eqnally murderous boiler, and work it on till some more people are killed, under the assuranee that when that occurs, he will, on the convocation of another learned coroner and his jury be again absolved, and once more set free to go on as before. Such a mode of inqniry conceals the truth instead of revealing it, and clearly protects the boiler owner rather than the public: the killer rather than the killed. This it is thonght is an inversion of the true order, and calls for correction. In conclusion, this explosion snggests two points for consideration: first, the neglect of inspection; secondly, the unsatisfactory character of the coroner's inqnest.

"Tabular Statement of Explosions from March 25th, 1871, to May 26th, 1871, inclusive.

Progressive No. for 1871.	Date.	General Description of Boiler.	Persons Injured.	Persons Killed.	Total.
15	May 3	Marine Multitnbnlar. Internally-fired	1	1	2
16	May 18	Portable Agricultural. Internally-fired	1	3	4
17	May 20	Portable Vertical. Internally-fired	0	0	0
18	May 22	Donble-flned, or 'Lancashire' Internally fired...............	3	1	4
19	May 25	Rag Boiler. No fire: heated by steam	1	0	1
		Total	6	5	11

"An Explosion springing from a Marine Multitubular Boiler.

"No. 15 explosion, by which one man was killed and another very seriously injured, occurred at about half-past four o'clock on the morning of Wednesday, the 3rd of May, on board a steam flat driven by a screw propeller. I have made a personal examination of the boiler from which the explosion sprung, and in preparation for giving evidence, in compliance with the request of the coroner, at the inquest, have had drawings prepared showing its construction, and the manner in which it has rent. As, however, the inquiry is not yet completed, the adjourned inquest having been postponed in conseqnence of the continued inability of the man who was injured by the explosion to attend, it may perhaps be better for detailed particulars to be deferred till the next report.

"An Explosion from Wedging the Safety-Valve down with a Nail.

"No. 16 Explosion, by which one person was killed and three others were injured, occurred at about one o'clock on the afternoon of Thursday, May 18th at a farm. A report of this explosion was received the day after it occurred, and in the course of a few hours an officer of this Association started for the scene of the catastrophe. On arriving, however, next morning at the spot, which was a little more than one hundred miles from Manchester, he fonnd that the inquest had been held and all the fragments of the boiler cleared away, and carried off to some distance. The consequence was that the Inspector made no examination of the parts, bnt he gleaned from the owner of the boiler the following particulars. It appears that the boiler was of the locomotive multitubular type, generally adopted for portable agricnltural purposes; that it had been in the possession of the owner for about nine years, during which period it had been twice repaired, the last time very recently; that it was let ont for hire, as snch engines usually are, and at the moment of explosion was being attended by the owner's man who had had the charge of it for years. With the regard to the cause of the explosion, the Inspector was fnrther informed that the boiler was fitted with one safety-valve of lever construction, loaded with a spring balance, and generally screwed down to a pressure of about 50 lbs. on the square inch, but that after the explosiou a nail was found wedged in between the lever and the top of the guide, thus locking it fast. In this way the boiler was allowed to stand throughout the dinner honr, and just as the engine had been started, or was about to be started, the boiler burst, killing the attendant who had put in the nail. It was further stated that the boiler was rent into a number of pieces, and that no thinning from corrosion was found, the explosion being attribnted simply to excessive pressure consequent on the safety-valve being pegged down by the engineman in the way just described. This explosion was

certainly treated with great despatch. It occurred on Thursday, killing one man and injuring three others. The inquest was held and completed on the Friday, and the fragments of the boiler carried off to a distance of some miles on the same day. This despatch was not favourable to investigation, and, simple as the narration of facts appear with regard to this explosion, it would nevertheless have been more satisfactory if the fragments of the boiler could have been seen by the Association's Inspector, or if there had been scientific evidence at the inquest. Accepting the narrative as it is given, however, one or two practical suggestions may be founded upon it. Several explosions arising from the locking fast of the safety-valves of portable agricultural boilers have been recorded in the Association's Monthly Reports, and it has already been pointed out that these boilers, which clearly do not receive the most skilled attendance, should be fitted with such safety-valves as are of the simplest construction and the least open to tampering. With this view it has been recommended that an external dead weight safety-valve of pendulous construction should be adopted.* A great number of these valves are satisfactorily at work under inspection on stationary boilers, and it is thought they might be applied to portable ones, or at all events that they should receive a trial. Further, where safety-valves of lever construction are adopted, and the lever is passed through a guide, the guide should not form a complete eye so as to afford a convenient trap for a wedge, but be cut open at the top like a tuning fork. Had these two simple precautions been adopted, the engineman could neither have blown himself nor his master's boiler to pieces by pegging the safety-valve down with a nail.

"An Explosion from the Collapse of a furnace crown of a 'Lancashire' Boiler.

"No. 18 Explosion, by which three persons were killed and another injured, occurred at about ten minutes before twelve o'clock on the evening of Monday, May 22nd, at a seed crushing mill. The boiler from which the explosion sprung, was of the Lancashire type, and failed from the collapse of one of the furnaces, which rent at the crown, and thus permitted the issue of a torrent of steam and hot water, which scalded to death the three men already enumerated. As I have been summoned by the coroner, as in the case of No. 15 Explosion, to investigate this disaster, and report to the jury thereon, and as the adjourned inquest has not yet been held, it may be better to defer the consideration of details till the next report.

"No. 19 Explosion, by which one man was killed, occurred on Wednesday, the 24th of May, at a paper mill. This explosion took place in the South of England, and an officer of the Association has been despatched to acquire particulars. There has not however been time to complete the investigation for this report, and details will therefore be given on a future occasion.

"Steam Boiler Legislation.

"On the termination of the Easter recess, the Select Committee of the House of Commons appointed 'to inquire into the cause of steam boiler explosions and the best means of preventing them,' recommenced its labours, and held two public sittings at which the following gentlemen were examined:—Messrs. Wollaston Blake, of Messrs. James Watt and Co., Birmingham; John Ravenhill, C.E., London; Alfred Blyth, C.E., London; Reginald Wigram, of Messrs. John Fowler and Co., Leeds; William Anderson Easton, of Messrs. Eastons, Amos, and Anderson, London; Andrew Murray, C.E., London; Edward Alfred Cowper, C.E., London; James Burrows, C.E., London; Joshua Field, of Messrs. Maudsley, Sons, and Field, London; George Horton, Boiler Maker, London; John Dell, Engine Driver, London; Joseph Lambert, Engine Driver, London.

"The examination of these witnesses concluded the evidence taken, and the public must now await the report that the committee may draw up and present to Parliament. The executive committee of this Association have, as its members will be aware, entertained a strong objection to Governmental inspection, though at the same time they have desired to see some steps taken to prevent the present sacrifice of human life from the constant recurrence of boiler explosions. The measure they have considered the best adapted to attain this end was set forth in the evidence given by Mr. Hugh Mason before the select committee, and as this is a subject affecting the interests of the members of this Association as steam users, it may be well to give an extract from Mr. Mason's evidence on the present occasion:—

"*Extract from Mr.* Hugh Mason's *evidence, given on Thursday, March 16th,* 1871, *before the Select Committee of the House of Commons, appointed to consider the subject of Steam Boiler Explosions :*—

"'The great number of persons killed and injured, as well as the amount of property destroyed every year from explosions resulting from the use of bad boilers, the greater number of these catastrophes being preventible by the adoption of periodical inspection, plainly shows that the time has now arrived when the Government should interfere in the behalf of the public safety, more especially since most of those killed and injured belong to a class which is too weak, too poor, and too ignorant to defend itself, while many are women and children, having no interest in the use of the boilers from which the explosions spring, or control over their management. Under these circumstances, justice to the public demands that the Government should enact that no boiler should be worked unless periodically inspected by duly authorised parties, and certified from time to time as safe and trustworthy, I do not consider however that it would be advisable for the inspection to be undertaken by the Government, fearing lest such a system should prove harassing to the steam user, and obstructive to progress. Neither do I consider it advisable that it should be carried out by municipal authorities, fearing that in that case the inspection would emanate from so many independent centres that there would be a want of harmony in the system, and that the inspections would be contradictory, while on other grounds also I do not think such an administration would secure efficient inspection. Nor do I think it desirable that it be left, as it as been proposed, to the boiler owner to select and to pay his own inspector. Such a system would produce a description of competition that would be prejudicial to the value of the inspection. An inspector to be able to act impartially should be placed in as unbiassed a position as a judge or a juror. He should not be paid according as his opinion gives approval to those whose case he adjudicates. On this system the inspector would degenerate into a certificate vendor. The most indulgent inspector would secure the greatest amount of business, and thus the certificates, it is to be feared, would soon become so lax as to lose their value. Many cases come before us at our monthly meetings in which boilers have been examined and certified as safe by inspectors deemed to be competent by the owners, and then have burst a short time after with fatal consequences. I am at a loss to see how the plan of every boiler owner's selecting and paying his own inspector would secure the efficiency of the inspections, and unless this efficiency were secured the certificates would merely be a means whereby the owner might shift his responsibility which clearly would not tend to the public safety. In fact, this system might result in many cases in the legalisation of bad boilers. Instead of these systems just referred to,—all of which have their advocates,—I would recommend that the Government, after enacting as already explained that no boiler should be worked unless periodically inspected and certified by duly authorised parties, should delegate the task of administering that inspection to a national series of district steam boards, composed in the main, if not entirely, of steam users themselves. These boards to be empowered to make such bye-laws, rules, and regulations as might be necessary for the conduct of the service, and their operations to cover the entire country, a conference of deputies from each of the boards being held at least once a year so as to secure uniformity of action in all the districts. By such a measure the inspection would be enforced by law to render its adoption universal: it would be administered by the steam users themselves to prevent its becoming arbitrary; it would be founded on a national basis to secure its purity. In this way the interest of the public, and of the steam user would be alike protected. The views I have just expressed are not mine alone. In describing the national series of district steam boards, I have ventured to quote from a resolution passed at a general meeting of the members of the Manchester Steam Users' Association, held in the Town Hall, on Tuesday, the 28th of February last. The members were epecially urged to attend this meeting to consider the subject of Steam Boiler Legislation. The meeting was a crowded one, and by far the most numerous that we have had for years. At this meeting resolutions were passed unanimously to the effect that inspection should be enforced by the Government, but administered by a national series of district steam boards. Having given the general idea of a system of administration by a national series of district steam boards, I may enter a little more into detail.

"'Number of District Steam Boards:—Let the whole country be mapped out into as many districts as may be thought advisable, and let there be established a centre of operation in each of these districts. The precise number of these districts would be a matter requiring a good deal of consideration, and it is not intended on this occasion to give a final opinion thereon, but simply to sketch out a plan of subdivision, in order the more fully to illustrate the system proposed. Let England and Wales be divided into, say, nine districts, one having Newcastle for its centre, a second Leeds, a third Manchester, a fourth Derby, a fifth Birmingham, a sixth Merthyr Tydvil, a seventh Bristol, an eighth Plymouth, and a ninth London. Also let Ireland and Scotland each have their own board, or, if necessary, their own series of district boards.

"'Constitution of the Boards:—The boards to be representative and honorary bodies, consisting of about twelve members, but this number to be open for further consideration. About 3-4ths of the members

* For previous references to this subject, see Association's Monthly Reports for January, 1865, No. 3 Explosion; January, 1866, No. 6 Explosion; May, 1866, No. 21 Explosion; October, 1866, No. 29 Explosion; May, 1867, Nos. 6 and 7 Explosions; November, 1867, No. 23 Explosion; November, 1868, under head "Improper Treatment of Safety-valves."

of the board to be men of commerce, that is to say, millowners and others, using boilers for mercantile purposes. The remainder to be men of science, that is to say, engineers, chemists, or others, competent to advise on matters affecting the inspection of boilers, or the interests of steam users generally, and to add weight to the councils of the board. Three of the men of commerce, and one of the men of science to retire every year, but to be eligible for re-election, so that every three years the boards would be entirely recruited, either with new members or re-elected ones.

"'APPOINTMENT OF THE BOARDS:—The appointments for vacancies open to men of commerce, three of which would occur every year, to be made by the popular election of the general body of boiler owners, the possession of every certified boiler giving its owner the privilege of a vote, so that the possession of two certified boilers would confer two votes, three certified boilers three votes, and so on. The elections to be conducted by means of nomination and voting papers, transmitted through the general post-office. Since a complete record would be kept of the names and addresses of all the steam users in every district, with the number of boilers belonging to each, and as their signatures could be readily identified, there would be no fear of fraudulent votes; while, further, a printed list showing the distribution of votes to each candidate, could be sent to each boiler owner before the final declaration of the poll, whereby each voter would be converted into a scrutineer. In this way all errors would be readily detected, and the publicity of the process would promote its purity. It is estimated that the expense of the elections conducted in this way would not exceed 4d. or 6d. per boiler. The appointment for the vacancies open to men of science, one of which would occur every year, to be made by a public functionary, thus:—Let four of the leading corporations in each district be selected, and let each of these in rotation appoint a man of science to a seat at the board year by year. If thought desirable this privilege could be restricted to one or two corporations, or on the other hand it might be extended to a greater number. In the event of an insufficient number of candidates being duly elected from time to time by the general body of steam users, to recruit the board, or in the event of any of those elected being unable to retain their seats through illness, death, or any other cause, the sitting board to be empowered and instructed to appoint appropriate persons to fill up the vacant seats. Also in the event of any of those members of the board elected by public functionaries being unable to retain their seats through illness, death, or any other cause, the public functionaries, who appointed such members, to be empowered and instructed to appoint others in their place. But those elected in the place of others who have vacated their seats through illness, death, or any other cause, to take up only the unexpired tenure of office appertaining to those seats, so that the rotation in the elections may not be disturbed. No doubt other means of appointing the boards might be adopted if preferred. The above is not essential to the integrity of the system proposed.

"'MODE OF ENFORCING INSPECTION:—Should a steam user persist in over-running a certificate after receiving notice thereof, it would then be the duty of the board to lay an information before the magistrate or other appropriate authorities, who should be empowered by the Steam Boiler Inspection Act to levy a fine for each day's offence, or adopt more summary measures if found necessary. But should a steam user persist in working on a boiler after it had been condemned as unsafe, and should the board report that life was jeopardised by its use, the magistrates to have the power at once to stop the working of the boiler.

"'ANNUAL REPORT:—The steam board of every district to present to its constituents year by year a report, giving the number of boilers under inspection, the boilers being classified according to their varieties of construction and working pressures, &c. Also the number of inspections to be given, as well as their character, *i.e.*, the number of external, internal, flue, or entire. Also the results of these examinations, *i.e.*, the number of certificates granted, and the number of defects met with. The report also to contain a financial statement, duly audited by independent public accountants, showing the receipts and expenditure. Added to this the report might be made the vehicle of conveying to boiler owners information on all matters of interest met with in the rounds of inspection, with regard to the construction and management of boilers, and thus be the means of diffusing much valuable information. The reports from all the districts to be bound together, and forwarded to the members of both Houses of Parliament, and also to be open to the purchase of the public generally at cost price.

"'EXAMINATIONS AND CERTIFICATES:—Every working boiler, whether in partial or continuous use, to be inspected at least four times a year. On one of these occasions, and more frequently if necessary, the boiler to be examined "entirely," that is to say, both inside and outside, when at rest and suitably prepared. The other examinations under ordinary circumstances need only be external, and may be made when the boilers are at work. Every new boiler and every second-hand boiler to be examined both inside and outside before leaving the maker's or vendor's yard, and also to be tested by the hydraulic pump to about twice the pressure at which it is to be worked under steam, the boiler being carefully examined and gauged while under the hydraulic test. Also the boiler to be re-inspected when laid down on the purchaser's premises, so that the entire complement of fittings may be examined as well as the brickwork seating, should there be any, before the boiler is put to work. Certificates, remaining in force not more than twelve months to be given after such "entire examination, should such examination prove satisfactory. These certificates to be confirmed at every external examination, and to be renewable year by year on a satisfactory "entire" examination being made of the boiler in question.

"'RESPONSIBILITY INCURRED BY THE ISSUE OF CERTIFICATES:—The issue of certificates would not unduly remove the responsibility of the owner. The system of inspection would be responsible for the safety of certified boilers, as far as their construction and condition were concerned, these being points with which it could fairly grapple, but it would not be responsible for defects arising from default of the attendant, such as neglecting the water supply, &c., over which it could not have complete control. A boiler owner is incompetent as a rule to decide upon the safety of his boiler either as regards its construction or condition. From this responsibility inspection would relieve him. But he is the most competent party to decide on the trustworthiness of his boiler minder, and to secure the faithful discharge of his duty, and, therefore, this task would be left to him to fulfil. Thus inspection would be responsible for the construction and condition of boilers, and the owners for their management.

"'ANNUAL CONFERENCE:—In order to secure the united action of the different boards and prevent the inspection of one district contradicting that of another, it is proposed that an annual conference should be held, to which each board shall send up some two or three of its members, as well as its chief engineer, as delegates. To ensure the due representation of the public at this annual conference, the presidents of the institutions of civil engineers, and mechanical engineers, and possibly of other learned societies, to have a seat, *ex-officio*, at the meetings; while, further, if thought desirable, two other engineers, appointed by the Board of Trade, might have a seat at the conference. At this conference the various plans of inspection adopted in the different districts, and the success attending them, to be fully canvassed, and such general rules laid down for the conduct of the service as might be found necessary to secure harmonious action throughout the entire system. To assist in this discussion, an interchange of annual reports from each district to be made prior to the meeting. This conference might, if thought desirable, itinerate, in the manner adopted by several of the learned societies with regard to their annual gatherings, such of the leading centres being selected as would be mutually convenient to all parties, and agreed upon at the annual meeting.

"'ADVANTAGES SECURED BY THE ADOPTION OF THE STEAM BOARDS:—The steam boards would relieve the Government of the responsibility, whether financial or scientific, that it would otherwise incur were it to undertake the inspection of all the boilers in the country. Also it would be more generally congenial to the tastes of steam users to have the inspection administered by boards of boiler owners than by the Board of Trade. Also the national series of district steam boards would secure an efficient system of inspection, combined with a mild administration, while that efficiency could not be secured were the inspection to be administered by municipal authorities, or were it undertaken for profit by independent competing companies or private parties. Added to this a national system of inspection carried out by the steam boards, would afford the means of registering every boiler in the kingdom, and also of diffusing much valuable information among the general body of steam users, and be a help and not a hindrance to engineering and commercial progress.'

"What measure the select committee may determine on recommending to Parliament, cannot be known till the report is presented, but it is earnestly trusted that it will be one calculated to secure two objects, the one, to save human life, and protect the public from the danger of steam boiler explosions: the other, to protect the steam user from undue Governmental interference."

L. E. FLETCHER,
Chief Engineer.

The following letter has been received from Sir Wm. Fairbairn, president, referring to the preceding subject.

My dear Sir,—Several of the statements given in evidence before your Committee with regard to the working of the Manchester Steam Users' Association were so contrary to fact that I think I should be wanting in my duty, as President of that Association, were I not to endeavour to

remove the mistaken impressions which those statements were calculated to convey.

Mr. Edward Alfred Cowper, who gave evidence at the conclusion of the inquiry, stated that, judging from the reports of the Association, the proportion of explosions springing from boilers under its inspection was one to every 2,000 boilers enrolled, and thns that it was as high as that prevailing throughont the entire country, so that there were as many explosions from inspected boilers as from those that were uninspected. Earlier in the inquiry Mr. McNaught stated that the number of explosions that had sprung from boilers enrolled with the Manchester Steam Users' Association was greater than that springing from those enrolled with the Manchester Boiler Insurance Company; while Mr. Longridge corroborated this in his last annual report, a copy of which, I am informed, was sent to every member of the select committee.

These statements that the boilers under inspection give rise to as many explosions as those not under inspection, and to more explosions than those under insurance, are calculated to damage the principle of inspection which this Association has done so much to promote, and, therefore, I wish to correct them. That correction may readily be made, and is as follows:—It is well known that the Manchester Steam Users' Association, which was founded as much as seventeen years ago—years before the existence of any of the insurance companies—was the first to practically develop the principle of periodical inspection. In doing this many difficulties had to be overcome. The work was a new one, not only to the execntive of the Association, but to its members. It was at this early stage of the Association's history that the explosions on which these calcnlations are based occurred, while its more recent experience, which completely contradicts those calculations, has been ignored. It must be remembered that this Association has always been a volnntary one, and has had no compulsory powers. In consequence of this considerable difficulty has been experienced from the want of full co-operation by the members. The Association from the first made provision for affording its members at least one "entire" examination of their boilers every year, bnt for a long time very few of the members availed themselves of this opportunity. After a while the Association succeeded in getting an annual "entire" examination of one boiler out of every three enrolled, while by continued perseverance for a course of years it advanced to an annual "entire" examination of two boilers out of every three enrolled. The Association then adopted a description of permissive compulsion. It started the guarantee system, which acted as a spur to inspection, inasmuch as the gnarantee is withheld from those boilers that are not allowed by their owners to be examined "entirely" every year, or of which the construction or condition are not approved by the Association. Since the possession of this compulsory power matters have greatly improved, and no explosions have sprung from boilers guaranteed by this Association, with the exception of one of an unimportant character, and which arose from exceptional circumstances, the owner injudicionsly making use of large quantities of composition for removing incrustation, while at the same time blowing-out was given up; in consequence of which the water was loaded with deposit, and the furnace crowns thereby overheated, when one of them rent, though no damage was done to persons or snrrounding property.

Many consider that the collapse of a furnace crown should not be termed an "explosion" at all, and this is the general view; but inasmuch as there was a rent, and the steam and hot water rushed out with violence, the Association has always termed it an explosion, though against itself. This is the only explosion, if such it may be called, that has occurred to a guaranteed boiler since the system was adopted at the commencement of 1865, which, having regard to the number of boilers guaranteed since that time, would bring the rate of explosion with the boilers nnder this Association to one in 10,000 per annum, while if this were not regarded as an explosion it would bring the number to *nil*.

This, I think, will be considered a full answer to the statements of Messrs. McNaught, Longridge, and Cowper. Now that we have more control over our members our rate of explosion is but one in 10,000 boilers per annum, while Mr. Longridge states that their rate is one in 4,600, so that it is just twice as high as that of the Manchester Steam Users' Association.

It shonld be remembered that the insurance companies have enjoyed the right of selection from the commencement of their operations, and, as given in evidence, have regnlarly rejected a per-centage of the boilers applying to them for enrolment. After making this selection, therefore, they should not have any explosions at all, except such as might be considered quite extraordinary, and beyond the control of the inspector.

To the above explanation I would wish to add the statement that the experience of our Association shows that there is a growing tendency on the part of boiler owners to seek an indemnity in the event of explosion, rather than prevention from such a catastrophe by sound inspection, and in illustration of this I may trouble you with a copy of a recent letter, while I may add that we have communications almost daily of a very similar character:—

"To the Secretary of the Manchester Steam Users' Association.

"Dear Sir,—In reply to your application for a renewal of my subscription, I beg to state that it is not my intention to continue it unless I have permission to work my boiler at 55lbs. pressure at least, which pressure is the same as I had used up to the end of 1870. Working at 50lbs. pressure—your present limit—during the last three months, I find will be insufficient when my water power becomes scarce. Moreover I do not see the necessity of insuring against a risk the existence of which I have every reason to doubt, if I only work the boiler at the limit of 50lbs. pressure. After your thorongh examination on Good Friday you will be better able to give me your limit. When I see your report I shall be better able to judge. Awaiting yonr reply,

"I remain, yonrs trnly,

"———."

It should be explained that that letter was written after the receipt by the owner of a report issued by the Association, pointing out the unsatisfactory condition of the boiler cousequent on serions external corrosion, arising from dampness. It will not be overlooked that the writer offers to pay his subscription, if under these circumstances the Association would say the boiler was safe.

Any company, association, or individual inspector who wonld carry ont the inspection of boilers on the principle of easy virtue, and grant easy indemnities, stating that boilers were safe when they were not safe, would no doubt drive a roaring trade; and, plainly seeing there is a strong tendency in that direction, I beg to express my earnest hope, in which I am snpported by every member of our committee, that whatever measure the wisdom of Parliament may dictate, that it may be one that will promote in its pnrity sound periodical inspection as the only preventive for steam boiler explosions.

I have, dear Sir, the honour to be,
Your obedient servant,
Wm. Fairbairn, President.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

ON THE DURABILITY OF CAST AND WROUGHT IRON FOR ENGINEERING STRUCTURES, THE CAUSES OF CORROSION AND DETERIORATION, AND SUGGESTIONS FOR REMEDYING AND ARRESTING DECAY.

By G. J. Crosbie Dawson, Esq., Assoc. Inst. C.E.,
Vice-President of the Civil and Mechanical Engineer's Society, &c.

It is rather remarkable I always think, that our early engineers rarely used iron in any of their structures, and it is only within the last few years that the valuable properties of the metal seem to have been universally acknowledged by the whole profession as applicable to almost every kind of engineering work. There is no other substance of greater nse to man, being so well adapted to form such a variety of things, tools of almost every description, machines of all kinds, steam engiues, &c., aud there is no other metal more abnndant thronghout the world than iron, it is found in almost every inorganic body, and where iron ore is found in plenty there generally are seams of coal adjacent. Iron has been nsed from the very earliest times, we read of it in the 4th chapter of Genesis, and 22nd verse. We know that iron was exported from this country before the Roman invasion, and the Ancient Britons must have understood how to work the metal for forming their scythes, hooks, spear-heads, and implements of warfare. Undoubtedly we owe our great wealth and prosperity as a nation, to our endless supply of iron and coal. It is less than 100 years ago, however, that iron was first nsed in engineering strnctures. The very first iron bridge constructed in this country, was, I believe, the bridge at Coal Brook Dale over the Severn, built 92 years ago, consisting of semi-circnlar cast iron arched ribs, and the bridge over the River Wear at Snnderland, built in 1790, of cast iron, would probably be the second.

Telford constrncted many iron bridges, the first of which was that at Buildwas in Shropshire, across the Severn in 1796, built of arched ribs of cast iron. His suspension bridge across the Menai Straits was commenced in 1825. Rennie's Southwark Bridge over the Thames was commenced in 1815. It was at the time, and even still is, I believe, the largest cast iron span, that of the centre arch being 240ft. It was not until about the year 1832, that the first attempts were made to substitute wrought for cast iron, by rivetting rolled plates together and forming girders, by means of riveting horizontal to vertical plates with angle iron. (Though wronght iron plates had been used in the manufacture of steam engine boilers, and ships, many years previously. The first iron boat having been constrncted in 1822, at the Horseley Iron Coy's works

at Tipton.) But girders so made were nsed only in the construction of floors or as deck-beams in ships, until about 10 years later, when Sir William Fairbairn, patented several improvements and designed the tubular girder. The first tube of Robert Stephenson's great bridge, the Britannia, over the Menai Straits, was commenced in 1847, and the bridge was completed in 1850. The Conway Bridge was bnilt about the same time, and since then, owing to the great success of these works and the numerous experiments that have been made with iron, and the improvements that have taken place in its manufacture, wrought iron has been most extensively nsed for every kind of engineering work, bnt more particularly for bridges. On our old railways, how few iron bridges there are, and on our new railways, how few stone, brick, or timber bridges, but almost all iron. Our architects are now also nsing iron to a very great extent in their buildings. In the North Western Hotel, just completed, at Lime-street station, Liverpool, Mr. Waterhonse has used wrought iron girders for all the floors, passages, galleries, staircases, &c., and cast iron columns. Our fine old ships also, three-decker men-of-war, "the good wooden walls of old England" are now fast becoming a thing of the past, and are being replaced by a magnificent fleet of iron armour-plated vessels, and all these transformations have taken place within the last few years. A bridge, pier, breakwater, lighthouse, &c., built of iron would be as we all know, aboat half the cost of the same built with stone, but we know that the stone will stand for centuries if properly constructed, and with good foundations, whereas we do not feel quite so sure about the iron, as to its durability, not having had the experience of it. Although experiments of all kinds have been made by some of our most eminent engineers, to ascertain the specific gravity, tenacity, crushing force, and the breaking weights and deflections, &c., of different kinds of iron, varions shaped girders, &c., yet no really definite conclnsion as to the exact durability of iron in engineering structures, can be arrived at, though we can conjecture with tolerable certainty. Iron in its three different states or forms, viz., wrought iron, steel, and cast iron, thongh considerably lighter than most other metals as copper, brass, lead, &c., is by far the most tenacious of all them. An iron wire $\frac{1}{30}$th of an inch in diameter will bear a weight of 60lbs.

The tenacity of steel in lbs. per sqnarc inch			is 120,000.
Ditto.	wronght iron	ditto.	70,000.
Ditto.	cast iron	ditto.	19,000.

But time not permitting and the subject of this paper being the durability of wrought and cast iron, I must exclude steel, though I believe the time is not far distant when it will be extensively used in engineering constructions. Some hnndreds of miles of rails on the London and North Western Railway, have during the past year or two been relaid with steel rails. Mr. Kirkaldy has for some years been making a series of experiments on the resistance of plates of steel to crushing force, and Mr. George Berkley, in a paper read before the Institntion of Civil Engineers, abont this time last year, drew attention to the experiments which had lately been tried with steel, more especially Bessemer steel, which experiments he considered justified the adoption of the following conclusions :—

1. "That Bessemer steel would bear before rupture a minimum tensile strain of 33 tons per square inch of section, and stretch about 1in. in 12in. of its length.

2. "That the same material would bear either in tension or in compression, a minimum stress of 17 tons before the extensions or reductions of length per unit of strain became irregular or excessive, as compared with those which had preceded them, in other words, before the yielding point of the material was reached.

3. "That this material would probably contain about 45 per cent. of carbon, chemically combined with the iron, and,

4. "That this description of steel, if properly made and annealed, was as uniform in quality as wrought iron, and therefore might be employed (precantions being taken to test its quality as a substitute for wrought iron,) while allowing an increase of strain of 50 per cent. to be imposed upon it."

Of the innumerable ores and the varions formations in which iron is found, and of the preparation and smelting of the ores, &c., I will not now speak, bnt will at once proceed to the question as to the durability of iron, and the effects that the atmosphere, moisture, smoke, sea-water, changes of temperature, &c., have upon it. There is not the slightest doubt that iron absorbs to a certain extent the oxygen or the carbonic acid in the atmosphere, and gradually corrodes, and more so when subjected to changes of atmospherc, or exposed to the action of water, and especially sea-water. Other metals, such as copper or lead, when soldered or placed in contact with iron, act chemically upon it, and the iron more quickly softens and corrodes. For instance the iron railings round the parks and sqnares, and round the areas of houses, &c., invariably begin to corrode at the bottom, where they are bedded into the stone with lead. I was noticing the railings round Leicester Sqnare the other day, the iron at the bottom is, in many cases, entirely worn away or eaten to the thickness of a thin wire. Then again, the cast iron plates which were affixed, according to Sir Humphrey Davy's proposition, to the bottom of ships to protect the copper sheathing, very rapidly became softened, and the ordinary copper sheathing fastened to ships by means of iron rails invariably begins to corrode, as do also the nails, at the places of contact by galvanic action. Sea-water has the effect both of softening iron and oxydizing it, bnt the rate of oxydation is slow. Mr. Mallett states, after making several experiments, that "cast iron freely exposed to the weather at Dnblin, and to all its atmospheric precipitations, was corroded nearly as fast as if in clear sea-water, when the specimens in both cases were wholly unprotected." Donbtless if the iron is always entirely under water, oxydation goes on more slowly than when the metal is exposed alternately to air and water. However, as I before observed, the rate of oxydation is slow. The cast iron piles that the late Sir William Cubitt cased the entrance basin of the Lowestoft harbonr with in 1832, are now almost as perfect as when driven. The cast iron piles for Herne Bay pier were driven in 1838 by Telford, and those for Southend pier in 1844, and are still in a most perfect state, as also Rennie's dock gates at Sheerness. The cast iron piles in Margate jetty, erected in 1853, the wharf wall at Victoria Docks, the piers of Chelsea Suspension Bridge, of Charing Cross Railway Bridge, and of Lambeth Bridge, &c., show little or no signs of corroding. The latter, however, are in fresh water. Sea-water itself freqnently provides an excellent protection against oxydation to the iron in the shape of mollusks, which little shell fish completely cover and incrnstate the metal, and when this incrustation has been removed, the iron has been fonnd to be smooth and quite free from any deterioration by the action of the sea-water. The *softening* of cast iron, Mr. E. B. Webb tells us, in a pamphlet on "Iron Breakwaters," is a process not clearly nnderstood. He says, "cast iron will soften in cylinders and pipes used in mines, as well as in piles standing in sea-water; after softening under sea-water it will at times become hard again on exposure to the air." Cast iron *has* been taken np after immersion in sea-water, utterly decomposed, owing most probably to the iron having been cast of the softest metal, there being snch great variety in the qnality of cast iron. Great care should therefore should be taken in selecting a quality of iron suitable for the work in which it is to be nsed, as the power of the various classes of cast iron to resist the action of sea-water, will vary according to quality. The necessity of substitnting iron for wood or stone, in piers, lighthouses, breakwaters, &c., is due to the perishable nature of the former and the costliness of the latter. Mr. Webb in his pamphlet says, "It appears that the action of the sea-water is powerfnl in the greatest degree, when the iron is composed of large crystals, and especially when there is irregnlarity in the crystallisation. It may be said that the softer the iron the greater is the liability to decomposition. Between the limits of extreme softness and decay on the one hand, and extreme hardness and durability, with brittleness, on the other, we have to make the selection. It has been stated that chilled cast iron corrodes faster than green sand castings, that all casting intended for use in sea-water should be cooled in the sand to insure uniformity in the crystals, and that Welsh iron is the best."

I will now turn to that portion of my snbject, which I think will be of most interest, viz., the application of cast and wronght iron to bridge construction. Wrought iron, as I before stated, was not, nntil about 30 years ago, employed in bridge construction, thongh cast iron has been made use of for nearly one hundred years. Now, however, cast iron is not employed as much as formerly, for althongh cast iron has greater power to resist crushing strains and is therefore preferable for columns, supports, and struts, &c., the crushing force of cast iron in lbs. per sqnare inch being about 92,000, and that of wrought iron about 38,000, yet for girders for bridge construction, the same amount of dependence cannot be placed in it as in wrought iron.

Mr. Rennie, some years ago, made a series of experiments on the effect of the changes of ordinary temperature on cast iron, particularly on the cast iron arches of Sonthwark Bridge, which is the largest cast iron span, I believe that there is, and he found that the rise in each arch, the span being 240ft., and the versed sine 23ft. 1in., is about $\frac{1}{50}$th of an inch for each degree of Fahrenheit, making $1\frac{1}{4}$in. for a difference of 50°. The arches have no alternative but to rise or fall, being bedded against the abutments. Cast iron arches are of course on the same principle as stone or brick arches, and derive their strength and stability by transferring the effect of the loads placed upon them to the abutments. Cast iron is chiefly now, however, used in bridge constrnction in the form of horizontal girders, and especially on railways, where we are frequently pinched for headway, as the depth of the structure is merely that which is required for the flanges of the girders.

40ft. is generally considered the maximum span for cast-iron girders, but the practice on the London and North Western Railway latterly has been, never to employ cast iron for spans over 25ft. It is certainly not so safe as wrought iron, and the

same degree of dependence cannot be placed in it. When testing the girders at the foundry, it is impossible to tell whether an extra ton of strain to the amount applied, would not have broken them. Then we can never be quite sure of perfect eastings, of perfect uniformity in the flanges, of the absence of air bubbles, &c. Then, again, in nine cases ont of ten, girders are cast on their sides at the foundry, in order to save time and trouble, and the consequence is that one edge of the flange as also one side of the web, consists of the scum of the iron, and another great objection to this mode of casting is the difficulty of preventing lateral twists in the girder. By having the girder cast upright, standing on its bottom, all this is avoided, the spurious part of the iron will be iu the top flange, where it is of no mnch consequence, and the girder is more likely to be perfectly straight. In my opinion, engineers shonld always have a special clause inserted in their specifications, insisting on the girders being cast upright. The cheapness of cast iron is in its favour, being about half the cost of wrought, but the cost of wrought iron *now*, is even less than I have known cast iron to be, the prices fluctnate so very much. On the widening of the Trent Valley Railway, on which I am the resident engineer, the price of wrought iron in girders including riveting, testing, painting, and fixing complete, is only £13 10s. whereas in 1861, the price for the cast-iron girders on the Edge Hill and Garstou Branch Railway was £13 10s. Since I have been an assistant engineer on the London and North Western Railway during the last ten years, the prices of ironwork have varied from £22 to £13 10s. per ton, for wrought-iron girders complete in every way, for bridges of ordinary spans, and from £13 to £7 per ton, for cast iron girders complete in every way, the lower prices being those at the present time. In practice, however, the difference in cost between wrought and cast iron is not after all so great, as owing to the thick flanges of east-iron girders, the weight of them is nearly double that of wrought-iron girders of the same size. It is found that wrought iron corrodes rather faster than cast iron. Mr. Mallett gives the relative oxidation in moist air as follows:—

Cast iron	·42
Wrought iron	·54
Steel	·56

He also states that the depth of corrosion of plates of Low Moor iron, as dedneed from his experiments, would be in one eentury.

In clear sea-water	·215 of an inch.	
In foul sea-water	·404	„
In elear fresh-water	·035	„

Mr. Baker, the engineer-in-chief of the London and North Western Railway, and Mr. Ramsbottom, the mechanical engineer, together with Mr. Lee lately inspected and thoroughly examined the Britannia and Conway tnbes, both externally and internally, and found the former bridge in excellent preservation, having been recently painted, but portions of the underside of the cellular top of the Conway tube, which had not been painted for four years, and which caught the smoke of the engine chimneys showed very slight signs of corrosion. They had some of the "scale" removed from the plates, and Dr. Percy analysed it and found it to contain about 41 per eent. of metallic iron. The accompanying table shows the details of analysis:—

Scale from the Conway Tube.

First analysis of Dr. Perey from the two following samples, which were rubbed and scraped from one and the same area of the same plate.

No. 1.	No. 2.
From that rubbed off an area of plate 2′.4″ × 1′.9″	From that scraped off an area of plate 2′.4″ × 1′.9″
Grains.	Grains.
Total weight............2810.7	Total weight............1316.3
Containing ....1229.9 of iron	Containing .... 532.8 of iron
or 43.65 per eent. of metallie iron.	or 40.48 per cent. of metallic iron.

Detail of composition.	Per cent. of total of the above quantity.	Detail of composition.	Per cent. of total of the above quantity.
Peroxide of iron	58·43	Peroxide of iron	54·90
Protoxide of iron	3·34	Protoxide of irou	2·64
Metallic iron	0·15	Metallic irou	traccs.
Protoxide of load	2·29	Protoxido of load	1·11
Copper	traces.	Copper	traces.
Sand (chiefly silica)	10·90	Sand (chiefly silica)	14·95
Carbonaceous matter (soot)	4·97	Carbonaccous matter (soot)	5·70
Water	15·23	Water	15·65
Sulphuric acid	3·30	Sulphuric acid	4·14
	98·61		99·09

Second analysis by Dr. Percy, from the two following samples, which were rnbbed and scraped from one and the same area of the same plate.

No. 1.	No. 2.
From that "rubbed" off an area of plate 3′.0″ × 1′.9″	From that "scraped" off an area of plate 3′.0″ × 1′.9″
Grains.	Grains.
Total weight............4614.	Total weight............5703.3
Containing ....1912.1 of iron	Containing..............2255.7 of iron
or 41.44 per cent. of metallic iron.	or 39.55 per cent. of metallic iron.

The plates from which the rust was taken are ½in. thick, and Mr. Baker says, that assuming the whole of this per centage did belong to the original iron plates, it would lead to the conclusion that nnder a continuation of similar circumstances, a period of time amounting to upwards of 1,200 years, would be required for the entire corrosion of the plate. Messrs. Baker and Ramsbottom recommend that the painting of the tubes from time to time be continued whenever the paint shows the least symtoms of decay, and that the paint selected for this purpose shonle be of a first rate quality aud analysed before being used, to see that it does not contain any matter injurious to the iron, and with such precautions they cannot give any practical limit to the endurance of these magnificent structures. These bridges have been built abont 20 years. The sensibility to changes of temperature of the tubes of the Britannia Bridge, owing to their large surface, is very remarkable. The tubes become curved towards the point from which the sun shines, so mnch so, that between sun rise and sun set, the centre is lifted fully an inch, as well as drawu sideways throughout an equal space. The total length of the Britannia tnbular bridge is 1,513ft., and an increase of temperatnre of 26° Fahrenheit only, causes an increase of length of 3¼in.

Professor F. Grace Calvert, at a recent meeting of the Manchester Literary and Philosophical Society, read a most interesting paper on the oxydation of iron. He gave the resnlts of a series of experiment he had made, at the instigation of Sir Charles Fox, to prove whether the oxydation of iron is due to the direct action of the oxygen of the atmosphere, or to the decomposition of its aqueous vapour, or whether the very small quantity of carbonic acid which it contains determines or intensifies the oxydation of metallic iron? The conclusions he arrived at are that "pure and dry oxygen does not determine the oxydation of iron, that moist oxygen has only feeble action; dry or moist pure carbonic acid has no action, but that moist oxygen containing traces of carbonic acid acts most rapidly on iron, giving rise to protoxide of iron, then to carbonate of the same oxide, and last to a mixture of saline oxide and hydrate of the sesquioxide of iron. These facts tend to show that carbonic acid is the agent which determines the oxydation of iron, and jnstifies the assumption that it is the presence of carbonic acid in the atmosphere, and not its oxygen or its aqueous vapour, which determined the oxydation of iron in common air. Although this statement may be objected to at first sight, on the ground of the small amount of carbonie acid gas existing in the atmosphere, still we mnst bear in mind that a piece of iron when exposed to atmospheric influences comes in contact with large quantities of carbonic acid during twenty-four hours." Professor Calvert ends his paper by stating as a fact "that carbonic acid promotes oxydation," and that "caustic alkalies prevent the oxydation of iron." He also states "that the carbonates and bicarbonates of the alkalies possess the same property as their hydrates," and "that if an iron blade is half immersed in a solution of the above mentioned carbonates, they exert such a preservative influence on that portion of the bar which is exposed to an atmosphere of common air (oxygen and carbonie acid), that it does not oxidise even after a period of two years. Similar results were obtained with sea-water to which had been added carbonates of potash and soda."

Mr. Baker usually has all wrought iron work immersed in boiling linseed oil, before leaving the manufactory, and afterwards painted with four or five coats of best oil paint, in order to protect the iron from rust. In most of his specifications he has a special clanse to this effect. There is not the slightest doubt, but that, if the above was always done, it wonld effectually keep the iron from corroding for many years, and after a lapse of time, when signs of oxidation began to appear, if the iron was again carefully cleaned and repainted, corrosiou wonld be entirely prevented. Bnt very ofteu the above precautions are not taken and the iron does not get thoronghly painted, and frequently there is rust on the iron beforc receiving tho first coat of paint. A resident engineer cannot be too careful in seeing to these matters. There are numerous anti-oxidation paints, one of the best of which, I believe, to bo Hubbnck's patent white zinc paint, as "by virtue of a semi-galvanic action on iron, it enters the pores and forms an amalgam of the two metals, which protects the iron from decay or incrustation." The old Hungerford Suspension Bridge was iu 1853 painted with the above, and it effectually preserved the iron from corrosion for ten years, up to the time of its being pulled

down for the new Charing Cross Railway Bridge. Another very good paint, from all accounts, is a silicated paint, supplied by "the Native Silicate Paint Company," as it causes the "substance of the paint to petrify" round the metal, and so preserve it, and it is said not to peel off. Small box girders, or tubular girders with cellular tops are objectionable on account of the large extent of surface exposed to corrosion, and of the difficulty there is in painting the inside; but by stopping up the ends of the cells so as to exclude the changes of atmosphere and moisture, the work of corrosion may be greatly diminished. One quarter of an inch, Mr. Stoney says, "may be assumed to be the minimum thickness that experience sanctions for the plating of permanent structures. A thinner plate than this may with care last for years, but few engineers would wish to risk the stability of any important structure on the chance of such frequent attention to prevent corrosion as so great a degree of tenuity would require."

The most important question of all, however, with respect to the durability of wrought-iron girders for bridges, &c., is, the amount of power of resistance that iron has to withstand repeated strains. It is of even more consequence than corrosion, and until lately has not been considered at all.

Sir William Fairbairn has recently been giving his attention to the subject, and making experiments to ascertain to "what extent vibratory action, accompanied by alternate severe strains, affects the cohesive force of bodies. It is immaterial whether the body be crystalline, homogeneous, or elongated into fibre, such as cast or wrought iron; the question to be solved is, how long will a body of this description sustain a series of strains produced by impact (or the repeated application of a given force) before it breaks? In the case of bridges and girders, this is a subject on which no reliable information has yet been given which may be considered as a safe measure of strength for the guidance of the engineer or architect." Sir William goes on to say, "of the resisting powers of material under the severe treatment of a continuous change of strain, such as that which the axles of carriages and locomotive engines undergo when rolling over iron jointed rails and rough roads, we are very imperfectly informed. Few facts are known, and very few experiments have been made bearing directly on the solution of this question. It has been assumed, probably not without reason, that wrought iron of the best and toughest quality assumes a crystalline structure when subjected to long and continuous vibration, that its cohesive powers are much deteriorated, and it becomes brittle, and liable to break with a force considerably less than that to which it had been previously subjected. This is not improbable, but we are apparently yet ignorant of the causes of this change; and the precise conditions under which it occurs." The breaking weight of wrought iron varies as we all know from about 20 to 24 tons per square arch of section, and the Board of Trade requirement in a wrought-iron bridge is that "the greatest load which can be brought upon it, added to the weight of the superstructure, should not produce a greater strain on any part of the material than five tons per square inch."

It is usual in specifications to state the particular description of iron to be used, and the amount of strain per square inch it is required to sustain without having its elasticity injured, and also the amount before fracture, and it is also usual for the engineer to have samples of the plates tested. Mr. Baker and Mr. Stevenson generally now have specimens forwarded to Mr. Kirkaldy for testing and experimenting upon. When examining wrought-iron girders at the works, I generally carry a stamp with my name on with me, and mark a plate with it, or a T or L iron, which I have cut out and tested, in order to ascertain if the same quality of iron has been used for the girders as was previously tested and approved of for the work. A soft, tough iron, if broken gradually, gives long silky fibres of leaden-grey hue, which twist together and cohere before breaking. A medium even grain with fibres denotes good iron. Badly refined iron gives a short blackish fibre on fracture. A very fine grain denotes hard steely iron, likely to be cold, short, and hard. Coarse grain with bright crystallised fracture or discoloured spots denotes cold short, brittle iron, which works easily when heated and welds well. Cracks on the edge of a bar are indications of hot short iron. Good iron is readily heated, is soft under the hammer, and throws out few sparks.

Sir William Fairbairn considering the Board of Trade requirement of five tons per square inch not sufficiently definite to secure in all cases the best form of construction, and that the margin, for errors of design and other practical defects being hardly sufficient, had a girder made purposely for experimenting upon, of 20ft. span, and of the following dimensions:—

Top plate 4in. × $\frac{1}{2}$in.
2 angle irons 2″ × 2″ × $\frac{5}{16}$″.
Bottom plate 4in. × $\frac{1}{4}$in.
2 angle irons 2″ × 2″ × $\frac{3}{16}$″.
Web plate $\frac{1}{8}$″ thick.

Depth of girder 16in., weight of it 7 cwt. 3 qrs., and breaking weight 12 tons.

Sir William Fairbairn in order to arrive at correct results and to imitate as nearly as possible the strain to which bridges are subjected by the passage of heavy railway trains, invented an apparatus specially adapted for that purpose, and designed to lower the load quickly upon the beam in the first instance, and subsequently to produce a considerable amount of vibration.

From the experiments made it was ascertained "that wrought-iron girders of ordinary construction are not safe when submitted to voilent disturbances with a load equivalent to one-third the weight that would break them. They, however, exhibit wonderful tenacity when subjected to the same treatment with one-fourth the load; and assuming that an iron girder bridge will bear with this load 12,000,000 changes without injury, it is clear that it would require 328 years, at the rate of 100 changes per day, before its security was affected. It would, however, be dangerous to risk a load of $\frac{1}{3}$rd the breaking weight upon bridges of this description, as according to the last experiments, the beam broke with 313,000 changes; or a period of eight years, at the same rate as before, would be sufficient to break it. It is more than probable that the beam might have been injured by the previous three million changes to which it had been subjected; and assuming this to be true, it would then follow that the beam was progressing to destruction, and must of necessity at some time, however remote, have terminated in fracture."

The following tables show the summary of results obtained by Sir William Fairbairn's experiments:—

First Series of Experiments.

Beam 20ft. between the supports.—Breaking weight 12 tons.

No. of experiment.	Date.	Weight laid on middle of beam in tons.	Number of changes of load.	Strain per square inch on bottom flange.	Strain per square inch on top flange.	Deflection in inches.	Remarks.
1	From March 21 to May 14, 1860.	2·96	596,790	4·62	2·58	·17	
2	From May 14 to June 26, 1860.	3·50	403,210	5·46	3·05	·23	
3	From July 25 to July 28, 1860....	4·68	5,175	7·31	4·08	·35	Broke by tension at a short distance from the centre of the beam.

The number of 1,005,175 changes was attained before fracture, with varying strains upon the bottom flange of 4·62 tons, 5·46 tons, and 7·31 tons per square inch.

Second Series of Experiments.

Beam 20ft. between the supports.—Breaking weight 12 tons.

No. of experiment.	Date.	Weight laid on middle of beam in tons.	Number of changes of load.	Strain per square inch on bottom flange.	Strain per square inch on top flange.	Deflection in inches.	Remarks.
4	August 9, 1860.	4·68	158	7·31	4·08	—	The apparatus was accidently set in motion.
5	August 11 and 12	3·58	25,742	5·59	3·12	·22	
6	From Aug. 13, 1860, to Oct. 16, 1861.......... ...	2·96	3,124,100	4·62	2·58	·18	
7	From Oct. 18, 1861, to Jan. 9, 1862	4·00	313,000	6·25	3·48	·20	Broke by tension as before, close to the plate rivetted over the previous fracture.

Here the number of 3,463,000 changes was attained when fracture ensued.

From these tables "it is evident that wrought-iron girders, when loaded to the extent of a tensile strain of seven tons per square inch, are not safe, if that strain is subjected to alternate changes of taking off the load and laying it on again, provided a certain amount of vibration is prodnced by that process; and what is important to notice is, that from 300,000 to 400,000 changes of this description are sufficient to ensnre fracture.

It mnst, however, be borne in mind that the beam from which these conclnsions are derived had snstained npwards of 3,000,000 changes, with nearly five tons tensile strain on the square inch, and it must be admitted from the experiments thns recorded that five tons per square inch of tensile strain on the bottom of girders, as fixed by the Board of Trade, appears to be an ample standard of strength."

Mr. Baker specified that the ironwork of the bridge over the River Mersey at Runcorn, which is one of the largest and finest of the bridges in this country, "shonld be of such quality as shall bear a strain of at least 14 tons per sqnare inch of sectional area, without having its elasticity injnred, and under this strain the extension of a bar 12ft. long by 10″ by 1″ shall not exceed ⅛th of an inch, and fracture shall not take place nnder any strain less than 22 tons per square inch of section."

Mr. George Berkley, in a paper read before the Institution of Civil Engineers, this time last year, stated "that the strength of wrought iron varied with the quantities of work involved in the production of the form of the material tested. This was proved by the fact, that a bar of iron one inch square, which would break with a strain of 26 tons, wonld, if drawn down to the form of wire $\frac{1}{32}$ of an inch in diameter, bear a strain of 40 tons per sqnare inch. The strength to be relied on in practice would probably be best represented by the minimum strain that one sqnare inch would bear without rupture, and by the amount of stretch which would take place in a given length before it broke."

Simplicity of construction is the great point to be aimed at in designing wrought-iron girders. Complicated arrangements should be avoided. All plates and parts of girders should be of the same pattern, easily pnt together, and accessible for preservation or repair. All rivet-holes shonld be drilled, as punching the plates undoubtedly weakens them, by straining the fibres of the metal; and all the ends and edges of plates and the butt joints of angle irons should be planed.

The resident engineer should himself see that all this is properly done at the ironworks; otherwise, with the present system of letting contracts to the lowest tender, and the contractor again in his turn sub-letting the ironwork to the lowest tender, inferior iron will be used, and rivet-holes will be punched, plates not planed, &c.; in short, bad work executed in every way, in order to make it pay.

So the resident engineer cannot be too careful in thoroughly looking after these matters, remembering the enormous responsibility on his shoulders, where the lives of the public are at stake.

INSTITUTION OF NAVAL ARCHITECTS.

ON THE EXAMINATION OF ADJUSTERS OF COMPASSES.

By Thomas Brassey, Esq. M.P., Associate.

Speaking on this snbject as an amateur sailor, my object is to befriend, as far as I can, our seafaring popnlation, a class for whom I have ever felt a most hearty sympathy. No skilful navigator, as I am well aware, will neglect the dnty of perpetnally testing, when at sea, the accuracy of his compasses by azimnths and other astronomical observations; but the difficulty with which we have to deal arises from the impossibility of testing compass errors in the cloudy and thick weather which so frequently prevails in our own latitudes. To provide the navigator, as far as possible, with the best means of safely navigating an iron ship, until he has had an opportnnity of making an independent verification of the errors of his compass, the Board of Trade require that the compasses of all iron ships should be properly adjnsted before they proceed to sea. With strange inconsistency, they have hitherto accepted, as evidence that that adjustment has been properly made, the certificates of persons for whose competency to undertake a very difficnlt and important task they had no guarantee. In the year 1865 the Royal Society entered into an interesting and valuable correspondence on this subject with the Board of Trade. The Royal Society stated that an organised department of skilful men, under able supervision, would probably be of much advantage, not merely in laying down rules, but in giving advice and suggestions to naval constrnctors, compass makers, and adjusters, and in producing a uniform system of adjustment. In support of their recommendation, they pointed to the fact that all the advances which have hitherto been made in the science, and which have placed England at the head of the science, are due to there having been for the last twenty-five years one officer, appointed by the Admiralty, to attend to this duty almost exclusively.

In September, 1865, the Admiralty, at the instance of the Royal Society, addressed a commnnication to the Board of Trade on this subject. They pointed out that in the Mercantile Marine there is no guarantee for the competency of the adjuster, and that regulations for the adjnstment of their compasses are thereby rendered in many cases inoperative, or nearly so. They admit that by constant practice, but without any very clear knowledge of the principles of magnetism, several skilful adjnsters of compasses are to be found at some of the great mercantile ports; but they declare that no system can be expected to be satisfactory which does not gradually develop itself under proper supervision. Notwithstanding this concurrence, on the part of the authorities at the Admiralty, in the views originally put forth by the Royal Society, the Board of Trade declined to accept the recommendation which had been made. I have made inquiry on the subject, and have reason to believe that no change has taken place in the views represented to the Board of Trade in 1865, both by the Royal Society and by the anthorities of the Admiralty.

A similar opinion is entertained by the Astronomer-Royal, who informs me that he assents most strongly to the requirements that, as a condition of seaworthiness, the adjustment of compasses should be carried out by a certified adjuster. "A condition eqnivalent to this," he says, "was urged by me on the Admiralty in 1839. All people who have at later times entered carefully into the matter have expressed the same opinion. I may cite particularly, Capt. Evans, Mr. Rnndell, and Mr. Towson, the examiner of the Local Marine Board of Liverpool." I have also consulted the committee of Lloyd's, and the oommittee of the Liverpool Shipowner's Association. Both of these associations are in favour of requiring that all adjusters of compasses should possess a certificate of competency. Such being the views entertained by men of science, by shipowners, and by insurance associations, I will now turn to one of the most interesting communications which I have received on this matter; interesting, becanse it comes from a highly distingnished officer of the mercantile marine, Sir James Anderson, whose practical experience of the difficulties of navigating iron ships gives the greatest possible weight to the opinion which he expresses:—"The compass is, of all other essentials, the most important part in the eqnipment of an iron vessel. It is of all others the least nnderstood, either by those who bnild ships, sail ships, or make the compasses that are used in the mercantile marine. My opinion is that there are not fifty officers now afloat, either in the Royal Navy or mercantile marine, who are conversant with the laws of magnetism, as affecting ships and compasses as they should be understood. The greater number of casualties to iron ships may be traced, in my jndgment, to errors of the compass and lee-way. When you reflect that a quarter of a point will cause about 2½ miles of error upon a hundred miles of distance run, and that after the nsnal observations about noon, or even during the afternoon, the steamers of the present day may easily run a distance of 200 miles before there is an opportunity of obtaining another observation, this would give an error of five miles in a ship's position. There can be no reason for objecting to a law which shall require that all compass adjusters at the seaports shall be men who have passed a strict examination, and that they mnst be properly certified by the compass department of the Admiralty."

I now proceed to consider the best mode of conducting the proposed system of examinations. If it should be thought impracticable to entrust the proposed duty to a department of the Admiralty, I would suggest that the Astronomer-Royal, Capt. Evans, the president of the Royal Society, an eminent representative of the shipowners, a representative of the insurance interests, and a practical nantical instrument maker of repute, would constitute a council, which, nnder the anthority of the Board of Trade, could readily consider the subjects in which candidates should be examined. Examiners could be appointed to act nnder the direction of the local marine boards, and condnct the examinations in the same manner in which the examination of masters and mates is now conducted in the principal ports. Mr. Rundell, from whom I have so often quoted, expresses the belief that when adjusters shall have passed an examination, and have been certified by the board as competent, it would be reasonable to require that they shonld be called upon to make a formal declaration that their work had been done in the best manner. "This," he says, "would tend to make an adjuster of compasses more particular, from the fear of the effect which any accident to a ship, which could be traceable to the compasses, might have upon his personal reputation as the holder of a certificate from the Board. It would also give him a more independent standing with shipowners." One merit which belongs to the proposals now made is, that while it would afford to all interested parties reasonable security that all iron ships holding a character from Lloyd's and the Liverpool registries, would be sufficiently and satisfactorily eqnipped as regards compasses, it would probably be

termed by the mercantile community "Government interference." To some, indeed, it may appear unnecessary that the Board of Trade should interfere in this matter; but, as Sir Frederick Arrow observes, though to the intelligent and scientifically-disposed officer the state of the law may be comparatively unimportant in this, as in all other matters, we should legislate for the stupid.

I can only say, in conclusion, that in my humble judgment, it is quite as necessary to secure a guarantee of the competency of the adjuster of a ship's compasses, as it is to require the possession of a certificate of the knowledge of seamanship and navigation in the officers responsible for the duties of navigation.

CHEMICAL SOCIETY.

ON BURNT IRON AND BURNT STEEL.

By W. MATTIEU WILLIAMS.

On page 7 of Dr. Percy's treatise on the "Metallurgy of Iron and Steel," he quotes the following conclusion of Mr. Riley:—"The property of becoming useless after exposure to a welding heat appears from the above experiments to be a special character of fnsed wrought-iron. The experiments have not been carried far enough to lead to any explanation of this: it may probably be due to the absence of a small quantity of carbon usually present in wrought-iron. In Bessemer's iron (Mr. Riley believes) there is no carbon, yet it certainly welds, thongh not very well."

Iron which has thus been damaged by reheating is designated "burnt iron" by the workman, who also gives the same name to iron which has been excessively heated and exposed after balling in the puddling furnace. It is worthy of remark that no amonnt of heat applied to the iron in the blast furnace or in the early stages of the pnddling process produces burnt iron. Bnrnt iron is brittle, its fracture is short and what is called crystalline; it has lost the fibrous character and silky appearance of good iron. If steel is raised to a bright-red heat, and snddenly cooled, it is rendered hard and brittle, bnt this hardness may be modified and brittleness diminished by the well-known process of tempering. If, however, the steel be raised to a yellow or white heat, and then be suddenly cooled, it is no longer capable of being tempered by mere reheating. It remains permanently brittle, and is worthless for the ordinary nses of steel, nnless it is again raised to a welding heat, and thoronghly rolled or hammered while hot, and then allowed to cool gradually. The fracture of burnt steel presents a very "coarse grain." It displays in a marked degree the so-called "crystalline" appearance. A careful examination, however, reveals something beyond a merely crystalline structure; for the facets of the aggregated grannles have a more or less conchoidal or rounded form. This has been observed by practical men, and the name of "toad's eyes" has been given to the concavities. As brittleness, and granular or "crystalline" fracture, and even toad's eyes may be due to other causes, it is sometime of considerable practical importance to be able to determine whether certain defects of a particular sample of iron or steel are due to original defects of the raw material, or to the carelessness of the workman, who may have burnt the iron or steel in subsequent stages of working. When engaged as chemist to large iron-works, I was very anxious to be able to solve this qnestion, bnt for a long time was unsuccessful. Karsten's theory, attributing the change to the absence of carbon, was shaken by the case of the burnt steel. This was also the case with the obvions explanation that the burning is due to oxidation. An accident finally removed a portion of the theoretical difficulty, and, at the same time, suggested a practical method of testing for burnt iron. An important part of my laboratory duty consisted in determining the percentage of carbon in Bessemer steel. Each blow was thns examined daily. Besides determining the carbon of the raw ingots, I frequently had to do the same for samples of rails, plates, tires, and miscellaneous samples of manufactured steel. As many as thirty or forty of such determinations were frequently made in one day. On one occasion, a trap was laid to catch the chemists by an excessively "practical" man, who was displeased by the detective revelations of the laboratory. Two samples of borings, marked "A" and "B," were sent for the carbon of the steel to be determined. My assistant reported that neither contained more than a trace of carbon—that neither sample was steel, bnt both were iron. I then examined them myself, and observed that they behaved very differently on the application of the standard nitric acid used for solution. When the acid was applied to sample A, the liquid at first became unnsually dark, suggesting a very large proportion of carbon. This colour gradually became less marked, and finally disappeared altogether, and when the solution was completed I fonnd no indications of carbon at all. Samp le b ehaved in the usnal manner of good iron, and only indicated a small trace of carbon—too small to be quantitative by determined by the colonr test.

Suspecting the presence of oxid in sample A, I repeated the experiment more carefully, and the observed that the dark colour of the liquid was due to snspended particles, kept in suspension by the effervescence, and that these particles were finally dissolved. Further examination proved that they were particles of oxid of iron entangled amidst the metallic iron. On inquiry, I learned that the samples were borings taken from the opposite sides of an armour-plate, one side of which was burnt, and the other side good. Sample A was from the burnt side. I afterwards obtained samples of iron burnt in different degrees, from such as were just perceptibly damaged to others that were quite rotten, and I found that, in all cases, there was a small quantity of oxid in the burnt iron, and that I could readily detect it by the very simple method of putting the borings into a nitric acid diluted to the specific gravity of 1·20. The burnt iron always gave a dirty appearance to the acid, which afterwards disappeared. This appearance is quite different from that presented by the acid in which similar borings of good iron have been placed. With a little practice in observing the normal appearance of good iron, and by using similar borings, the difference is easily detected, and thus a valuable practical laboratory test for burnt iron is afforded. This test is only applicable to borings from samples of clean finished iron—the silicon, graphite, and other impurities of pig-iron produce a similar dirtiness, which might be mistaken for that produced by the oxid. The dark colour prodnced by combined carbon is so different in its appearance that it is at once distinguishable, besides which, this is permanent. I examined samples of burnt steel in the same manner, but no indications of the presence of intermingled oxid were presented. This of course, was to be expected, as the carbon of the steel must protect it more or less completely from oxidation by heat. It thus appears that, although the mechanical peculiarities of burnt iron and burnt steel so nearly resemble, the respective chemical changes effected in the so-called burning are qnite differeut. A number of other facts go to show that the burning of burnt iron is simply a process of partial oxidation, and that therefore the term "burnt iron" is philosophically correct. An armour-plate, for example, is made up of a larger number of balls or blooms of puddled iron welded together. It is built up by welding puddled balls with slabs, slabs into moulds, and piling and welding these moulds into plates. These processes include several reheatings of the iron, and at each reheating the whole of these great masses of iron must be raised to a full welding heat. The rolling of a 4in. plate was formerly declared by all practical men to be an impossibility, until a remarkably enterprising man, then scarcely aware of the difficulties to be overcome, undertook to do it, and succeeded not only in reaching the four inches, but ultimately progressing to fourteen. One of the greatest difficnlties to be overcome was the reheating of these great masses without burning them, and opportunities of earning large wages were offered to the workmen who should superintend these furnace operations successfully. I known an illiterate black-faced workman, one of the pioneers in this enterprise, who earned as mnch as £40 per week by payments received on tonnage of work done nnder his direction, and have watched with great interest the mode of proceeding of this man and others who have successfnlly condncted such furnace operations. By varions devices, the philosophy of which they no not dream of understanding, they subject the iron to the action of a reducing flame only. I have peered into these great reverberatory furnaces or ovens at all stages, scorching my face, and inflaming my eyes continually, and, except at quite the early stage of the reheating, or the preparatory stages of heating the oven walls, have always fonnd a densely carbonaceons, obvionsly reducing flame to be the only one permitted to play upon the iron. One device I may specially mention on account of its simplicity, universality, and effectiveness. The great doors of the reverberatory chamber, through which the iron is introduced and withdrawn, are made to rise and fall by the action of a counterpoised lever. They are freqnently opened to examine the state of the pile, and do not fit closely. There is considerable air-space at the bottom. If this were left open, a supply of oxygen wonld find its way to the iron within. Withont any idea of the philiosophy of the practice, the workman places large lumps of coal just inside the doors in such a position that the entering air must pass them before they can reach the iron. This coal, intensely heated by radiation from the great flame and the white-hot furnace walls, is prepared to combine with more than all the oxygen that can enter, which thus passes forward as carbonic oxid and aqueous vapour.

I have made similar observations in other processes of iron working. Thus, when the puddler has called np his charge, *i.e.*, when it is no longer protected from oxidation by its own combined carbon, he closes his damper, and fills up the air-ways of his furnace with lumps of coal. He does this most carefnlly, just at the time when oxidation would be mischievous. He knows nothing about the theory of this admirable

device, and, as far as I have learned, no chemist has hitherto explained the philosophy of this carbon door, and why the puddler, instead of using an ordinary furnace-door so easily applicable, always has an iron ledge or shelf fixed in front of his fire-hole, on purpose for thus blocking it up with coal. The "stuff-hole" is also carefully stuffed with coal at the same time. Thus, it appears that, when iron is unprotected by combined carbon, it is oxidised not merely on its surface, but through its whole substance, if exposed at a sufficiently high temperature and for a sufficient length of time to the action of atmospheric oxygen. The possibility of such internal oxidation no longer presents a difficulty, the researches of Deville, Troost, and Graham having proved that red-hot iron is permeable by certain gases.

The Bessemer process illustrates the protecting action of combined carbon in a very striking and interesting manner. Mr. Riley mistakes in supposing that weldable Bessemer iron contains no carbon. I have made repeated analyses of Bessemer metal in which the carbon is reduced to the lowest proportion compatible with coherence, and find that this limit is reached when the carbon is reduced to about 0·2 per cent. in Bessemer metal prepared in the usual manner. The general practical limit is 0·25 per cent. This is well known to all practical manufacturers who are at all acquainted with the chemical composition of their steel. With less than 0·2 per cent. of carbon, the Bessemer iron crumbles under the hammer, and, if nearly free from carbon, it behaves like a piece of coarse sandstone. This is the ordinary condition of the iron at the termination of the "blow," and before the spiegeleisen is introduced. It is then a burnt iron of very exaggerated type, and is quite useless until it has been unburnt by the carbon of the spiegeleisen. The introduction of the spiegeleisen displays in a very beautiful manner the presence of the intermingled oxide. When the fused spiegeleisen is poured into the converter containing the fused material, which I shall call the melted burnt iron, a violent ebullition is visible, jets of carbonic oxide are forced through this burnt iron, and a huge blue carbonic oxide flame pours out of the mouth of the converter. The quantity thus poured forth fills completely the mouth of the converter; it is perfectly obvious that no air is entering at the same time, the blowing has ceased, and thus the only possible source of supply of oxygen for the formation of this great volume of carbonic oxide is within this melted burnt iron. If the quantity of spiegeleisen thus introduced is insufficient to supply a minimum surplus of 0·20 to 0·25 per cent. of carbon, the reduction of the free oxide is not completed, and the resulting product breaks under the hammer from mere want of complete coherence. In like manner, when the spongy balls of iron from a puddling furnace are first crushed down by the hammer, jets of carbonic oxide (to which the workman applies the universal name of "sulphur") issue forth. I have observed that this takes place most abundantly when the ball has stood for some time waiting its turn for the hammer, and believe that it is caused by the commingling of the superficial burnt iron with the inner iron which remains unburnt, and stil retains a small portion of carbon.

The manufacture of pure iron by the ordinary process is practically impossible, for immediately all the carbon is gone oxidation commences, and iron quite free from carbon will not bear the exposure which is necessary in the processes of forging, still less of fusing. By working in an atmosphere of carbonic acid, pure iron might be obtained. The amount of carbon necessary to prevent the iron becoming burnt varies with the severity of the oxidising exposure. The case of the Bessemer iron above cited is that of the maximum severity of exposure. The idea sometimes expressed that chemically pure iron would be unfit for commercial purposes is, I believe, a great fallacy. The nearer it approaches to purity, the greater its value for all purposes where toughness, malleability, and ductility are demanded. The great art of producing good armour-plates is that of working exactly up to the point where the carbon is reduced to its uttermost minimum, and where another reheating, even to bright redness, would produce burnt iron, the iron being also free from other impurities, especially phosphorus. I have already shown that burnt steel does not ontain the free oxide which by its presence destroys the continuity and cohesion of burnt iron. What, then, is the nature of the burning process in this case, and how does it produce the observed mechanical changes? The following facts may assist us to the required explanation. When engaged at the works of Sir John Brown & Co., at Sheffield, I frequently had to determine the carbon of rails, tires, plates, etc., made from known samples of Bessemer steel, from ingots of which I had already determined and recorded the percentage of carbon. In every case, where I had reliable opportunities of identifying the raw material, I found that the finished rail, etc., contained less carbon than the ingot from which it was made. The amount of difference, however was variable—was usually the greatest when the steel was the hardest, *i.e.*, when it contained the largest proportion of carbon. This reduction of the quantity of carbon varied from 0·02 to 0·10 per cent. The extreme of these limits was reached in the case of some hard steel plates, which, on account of their excessive hardness, were objects of special investigation. Now, the steel of these plates, or the ordinary rails, etc., are only heated to bright redness, then hammered, heated again, and rolled.

Another case. Some very brittle plates were made by rolling an unusually hard sample of Bessemer steel, containing 0·75 per cent. of carbon. Being engaged on some experiments on annealing, I secured some pieces of this plate, and heated them for periods varying from six hours to four days in an annealing furnace where the temperature was purposely retained at a dull-red heat. I then examined them mechanically, and chemically determined the carbon of their "skin" and of their interior at different depths from their surface. By the skin I mean the clean metal surface, after the scale was removed. This skin was shaved off for analysis by means of a flat-faced drill. I found that the skin of the piece of plate that had been heated during four days contained no carbon, or only a trace too small for determination, that this absence of carbon continued to a sensible depth, to about the fiftieth of an inch. (Having no means of accurate measurement, this estimation is but an approximation.) Below this, a sensible amount of carbon was detected, and this rapidly increased, till at a depth of about $\frac{1}{8}$th of an inch, it amounted to 0·72 per cent., and this without any sensible variation continued to the middle of the plate (which was $\frac{1}{2}$in. thick), and on to within about $\frac{1}{8}$th of an inch of the other side. All the other plates suffered a loss of carbon from their surface, but in lesser degrees, corresponding to the time to which they had been heated. I made several repetitions of such experiments, and found that, by exposing steel to open fires, the removal of the carbon from its surface and interior was much more rapidly effected. I do not bring forward these experiments as novelties, as I believe that similar experiments have been made by others. They show that the carbon of steel may be oxidised and removed without fusion or visible combustion; that a slow combustion of carbon takes place even at a low red heat, and that this combustion, like the opposite process of cementation, is not limited to the surface, but proceeds gradually inwards. The permeability of red-hot steel by oxygen and carbonic oxide enables us to understand the otherwise mysterious action of the interior oxidation of the carbon. Under favourable circumstances, it is probable that a considerable portion of the carbonic oxide thus produced may remain occluded in the iron. Let us now suppose that we have a piece of steel at the welding or pasty heat, just at the temperature most favourable for the most rapid endosmosis of oxygen and the exosmosis of carbonic oxide, and that, while these actions are in full progress, we suddenly cool the steel, and arrest the possible occlusion of the carbonic oxide. The result would be the production of a certain degree of molecular disintegration and porosity of the steel, the minute arrested bubbles of carbonic oxide or oxygen producing a similar effect upon the cohesion of the burnt steel, and that of the particles of oxide upon the burnt iron. The "toad's eyes," or conchoidal facets of the so called crystals, are in strict accordance with this explanation, as also is the fact that burnt steel may be cured by reheating and hammering, or rolling at a welding heat, as at this temperature, and subjected to such pressure, the separated faces of the bubble-holes would be welded together, and the gases either occluded or driven out. All steel presents a "grain" or so-called crystalline structure, and this varies in its degree of coarseness. In ordinary hardened steel, the grain is coarser than in the same quality of steel when tempered or softened. My own conviction is that all steel and all iron is of spongy structure, that such a structure may even be common to all metals, that the so-called crystalline fracture of iron and steel is not due to crystallisation at all, but to a visible degree of porosity, and that the fibrous structure of rolled iron is merely due to a different arrangement and elongation of these mechanical pores. By pores and porosity I do not mean those imaginary interspaces between imaginary atoms in the midst of which our modern mathematicians so luxuriously revel, but actually visible and demonstrable spaces.

A further statement of the grounds upon which this view of the constitution of metals is based would carry me beyond the proper limits of this paper, and, therefore, with the permission of the president and council, I will bring this subject before the society on some future evening.

ROYAL INSTITUTION OF GREAT BRITAIN.

ON SEA WAVES.

By W. J. MACQUORN RANKINE, C.E. LL.D. F.R.S.

The speaker in the first place gave a summary, illustrated by diagrams and machines, of existing knowledge of the mode of motion of water in waves, and of the geometrical and dynamical laws which govern the relations between the depth of disturbance of the water, the velocity of advance of waves, their periodic time, and their length. He referred to the experimental and theoretical researches of previous authors on the subject, such as the Webers, Airy, Scott Russell, Caligny, &c.

He then explained the principle, of which Mr. Froude was the first to point out the importance, that the action of water agitated by waves upon a ship tends to make her perform the motions which would have been performed in her absence by the mass of water that she displaces. In still water, the forces of gravity and of buoyancy tend to keep the ship upright, and if she has been heeled over, to restore her to the upright position, and that tendency constitutes the statical stability or stiffness of the ship. Amongst waves the same forces, combined with the reactions due to the heaving motions of the water and of the ship, tend to place her in the position called upright to the wave surface; that is, with her originally vertical axis normal to the wave surface. If the ship yielded passively to that tendency, like a broad and shallow raft, she would accompany the waves in their rolling; and thus, a ship having great stiffness may be very deficient in steadiness. Every ship has, like a pendulum, a natural period of rolling, depending on her stiffness, or tendency to right herself, and her moment of inertia, being a quantity depending on the distribution of her mass. Stiffness tends to shorten, and inertia to lengthen, the period. It was shown in 1862, by Mr. Froude, that the greatest unsteadiness and the greatest danger of being overturned take place when the periodic times of rolling of the ship and of the waves are equal; for then each successive wave adds to the extent of roll; and if the coincidence of the periods were exact, the ship would inevitably be overturned in the end.

In the course of the present spring it has been pointed out that in well-designed ships a safeguard exists against the occurrence of such disasters. It is well known that no pendulum is absolutely isochronous; but great oscillations occupy a longer time than small oscillations. In like manner, no ship is absolutely isochronous in her natural rolling; but great angles of roll occupy longer periods than small.* Hence, supposing a ship to encounter waves of a period equal or nearly equal to her own natural period for small angles of roll, her angle of rolling is at first progressively increased; but at the same time her natural periodic time of rolling is increased, until it is no longer equal or nearly equal to the periodic time of the waves; and thus she in a manner eludes the danger arising from coincidence of periods. In order, however, that this safeguard may act efficiently, it is essential that the natural period of the ship for the smallest angles of roll should not be less than the period of the waves; otherwise the first effect of the progressive increase of angle will be, not to destroy, but to produce coincidence of period; and the result will be great unsteadiness of motion, and possibly great danger.

The speaker described the above principles as being the latest additions to our knowledge of the theory of the relations between ships and sea-waves; and he illustrated them by means of experiments on a machine so constructed as to imitate the dynamical condition of a ship rolling amongst waves.

* Note (added 2nd June). An exception to this rule exists in the case of that form of ship known as the *Symondite*, in which the sides flare out at and near the water-line, so as to make the stiffness increase faster than the angle of heel. In such ships the period of rolling shortens when the angle increases; and thus the well-known unsteadiness of large vessels of that model is accounted for. In a small boat, whose natural periodic time for the smallest angle of roll is shorter than that of any of the waves which she encounters, the *Symondite* model does not promote unsteadiness; for the shortening of the natural period of rolling removes it farther from coincidence with the period of he waves.

SOCIETY OF ENGINEERS.

THE TIMBERING OF TRENCHES AND TUNNELS APPLICABLE TO RAILWAY AND SEWERAGE WORKS.

By Mr. CHARLES TURNER.

Timber is required in constructing sewerage works, to support the sides of the narrow and deep cuttings required in building the drainage culverts and pipe drains, for centreing, drainage purposes and other special purposes hereafter mentioned. It is also required in tunnelling to support the sides of the shafts, and the roofs, and side walls of the headings; to carry the tramways, and for the construction of the long pump rods in the deep shafts. Also for centreing, drainage, trunks, and other special purposes. The manner of framing and introducing the timber depends greatly upon whether the timbering is to be only temporary, that is to say, merely to support the ground in advance of the masonry, or whether, as in the case of headings for a tunnel, it is required to stand possibly for several years.

Secondly, on the description and quality of the timber to be used; *i.e.*, whether the timber is to be round, half-round, or square timber; and what sort of timber and what sizes of it are available. It is usual for temporary work, such as that first mentioned, to use the timber that is the cheapest, the most easily and most economically transported, and which is the most saleable after it has served the temporary purpose required of it. If the timber is sufficiently good and strong for its work no objection can be taken to such a course, but it is often a very short sighted policy, as it is hoped to be shown presently. Before entering more particularly into a description of the timbering required for open cuttings for sewerage works, and for driftways, headings, &c., for railway tunnels, it will be well to set forth a few simple rules for carrying out such works of timbering generally. They are well known by all mining engineers, and most of them by any good practical miner. (1) All timber use should be of as hard and tough a nature as it is possible to procure for a reasonable cost. (2) All timber should be cut at the fall of the year, when the sap is down, and no timber ought to be used that has not had a certain amount of seasoning, having been kept either constantly wet or dry for not less than six months after it was felled. (3) All timber used should have been barked three months before using. (4) The best description of timber for shores, sills, posts, &c., is larch or fir; oak may be used occasionally to resist a great transverse strain. (5) The principal strain should in all cases be thrown as far as possible upon the end grain of the timber, or, in the case of waling pieces, sills or sleepers, which should always, if possible, be of half-round timber upon the rounded side of the timber. (6) All side pillars or side posts should be slightly oblique, forming with the head and ground sills the section of a truncated pyramid. The tenons of the pillars, &c., should be cut square, and the mortices in the sills at an angle to prevent lateral movement. (7) The timbers should be framed and fitted accurately; no spikes or bolts to be used to keep the timbers together; all wedging up to be avoided as far as possible, except in certain cases described hereafter. (8) All poling boards in headings, and the linings at the back of the curbs, where square shafts are timber-lined, should be pointed and driven obliquely, each set to overlap the preceding one. (9) All shores to be fitted to drive from above; and never in any case sideways or horizontally. When half-round timber is used for the waling the ends of the shores to be slightly bird's-mouthed, to fit to the shape of the timber. (10) As large a bearing surface as possible to be allowed where the end of one timber takes a bearing upon the face of another timber. (11) When planks, battens, or other square timbers are used for waling pieces, they should be bedded in the sides of the excavation at a slight angle, so that when the shore, cut to the proper angle, is driven down from above, it will always take a fair bearing over the whole of its surface. (12) Adjustable guages to be provided for taking the exact length and exact angle of ends of the timber required. (13) No timbers require to be fitted in their places more tightly than to take a fair bearing. If any strain is shown upon them they will be tightened far better and more in the direction required than by any artificial means that can possibly be used.

First, as to timber in open cuttings or for sewerage work. Most of these works are executed either in large towns or in the neigbourhood of them, and the timber used to support the sides of the excavations is either such as can be found in the place or can be most easily conveyed to it, fir scaffold poles, cut up into lengths, being used for the shores, and the cheapest description of battens or planks that can be procured for the walings. In many cases these are only used for form's sake and might readily be dispensed with. The common practice is to introduce tiers of battens, about 4ft. or 5ft. apart in depth, with round poles of from 4in. to 6in. diameter for shores. These are almost always driven sideways into their places, and even if well cut and fitted have but a comparatively small bearing upon the batten which forms the waling piece. If the cutting is dry these shores frequently become loose and drop down, as there is seldom any upright or support under them. In many cases this arrangement proves sufficient, as no timbering is really wanted, but when there is really a pressure exerted against the timber the waling planks or battens are very apt to split, from the shores being driven in sideways, and therefore bearing on a very small surface of the timber. If battens are used in the above manner it is much better to cut the excavation to a slight batter, and to let the battens or planks in parallel to the face, and to drive down the shores from above sufficiently tight to give the batten a firm bearing against the sides of the excavation. The lower tier of battens should be strutted up from the ground, and uprights should be placed at intervals between the tiers of battens, especially under the joints. When half-round timber can be procured it is generally preferable to the battens, as it has less tendency to split. In that case the flat side of the timber should be placed against the side of the cutting and slightly let into it, and the end of the shores should be slightly bird's-mouthed out to fit the round side of the timber, and should be driven down from above. If the ground worked through is of very shifting nature, such as thin strata of sand or clay, with water, it is often necessary to close-timber the cutting. In this case planks should be placed upright at intervals of from 5ft. to 6ft., with horizontal planks behind them, one upon the other; the usual round shores being introduced between the planks, which mu always be laid at a slight

angle, so that by driving down the shores from above the whole will be wedged firmly into its position. When the ground is very insecure the upright planks can only be driven in short lengths, the one being made to overlap the other. Of course a system of timbering comparatively so complicated should not be used unless absolutely necessary, and in many cases where there is sufficient depth of roof, it is better to carry on the excavation in short lengths and tunnel in between. But there are cases where tunnelling cannot be adopted, and it is better to go to any reasonable expense in timbering rather than to risk life. Besides the above reasons in many instances it is absolutely necessary to leave the timber in until the ground has become thoroughly consolidated. Unless such timbers are of the proper size, and have been well framed together, such a precaution is worse than useless, and it gives a fancied security which does not really exist.

(To be continued.)

INSTITUTION OF CIVIL ENGINEERS.

The members of this incorporated society held their last meeting for the session 1870-71 on Tuesday, the 23rd May, when the chair was occupied by Mr. C. B. Vignoles, F.R.S., the President. A report was brought up from the Council, which stated that, during the present month, Messrs. Robert Harvey Burnett, John Carruthers, Lewis William Pritchard, and Charles Henry Waring had been transferred from the class of Associate to that of Member, and Messrs. Thomas Milnes Favell, Joshua Percy Josephson, William Macdonald Matthews, John Narciso de Olano, and William Cort Starie had been admitted as Students. The ballot was then taken for the candidates recently passed by the council, and resulted in the election of Mr. Sandford Fleming, chief engineer of the Intercolonial Railway, Ottawa, Canada, as a member; and of Mr. Edward Banfield, manager of the Great Southern Railway of Buenos Ayres, Mr. Peter William Barlow, jun., Westminster, Mr. Walter Brandreth Bromley, assistant engineer P.W.D., India, Mr. Charles Toler Burke, Stud. Inst. C.E., Assistant Engineer for Irrigation, Dhoolia, India, Mr. Jabez Church, jun., Stud. Inst. C.E., Westminster, Mr. Charles John Geneste, late Contractor's Staff, Delhi Railway, Mr. John Lillywhite, Assistant Engineer, Admiralty Works, Portsmouth Dockyard, Mr. Joseph Newton, Royal Mint, and Captain George Swetenham, R.E., late Officiating Superintending Engineer, P.W.D., Hydrabad, as Associates.

It was announced that, during the session just concluded 25 members and 103 associates had been elected, and 50 students had been admitted, while 11 associates had been transferred to the class of member; and that there were now on the books 15 honorary members, 732 members, 1,061 associates, and 207 students, making a total of 2,015 of all classes. It was mentioned that at the same period in 1856, when the institution had been in existence between thirty-eight and thirty-nine years. the gross number of all classes was 797, in 1861 it had risen to 945, in 1866 to 1,339, and now it was 2,015, representing an increase of 153 per cent. in the fifteen years.

THE PRESIDENT'S CONVERSAZIONE.

The president Mr. C. H. Vignoles, F.R.S., with the able assistance of the secretary, Mr. J. Forrest, C.E., introduced at this meeting some novelties in the arrangement of the exhibits which were undoubtedly decided improvements. It was generally agreed that this conversazione was one of the most successful that has as yet been held in Great George-street.

Although perhaps the "fine arts" can scarcely be termed a branch of civil engineering, the pictures here exhibited were decidedly calculated to produce that impression. They invariably included some engineering subject and lighthouses, bridges, viaducts, &c., were illustrated in considerable profusion, besides which there were a number of portraits of celebrated engineers.

As regards the models and instruments illustrative of different branches of engineering, a regular series upon one subject was collected together, making a far more complete and instructive arrangement than that heretofore followed. In some branches the series was remarkably complete; such for instance as those illustrative of electro-telegraphy to which the Postmaster-General, Messrs. Siemens and Co., Sir Charles Wheatstone contributed, together with Sir William Thomson's syphon recorder. This latter exhibit formed one of the most interesting exhibits of the evening.

There was also a very complete collection of various apparatus connected with water supply, including schemes specially adapted for constant service which is now being so much agitated for introduction to London; and also various sanatory contrivances that are much needed for the same city.

Another interesting collection consisted of a very complete series of arms of precision, including rifles of foreign countries, but chiefly illustrating the progress made in arms of a similar description in this country. Connected with this subject, were exhibited a great variety of specimen of gunpowder as at present employed by various nations, and including the new pebble powder recommended for our large guns.

Amongst the more mechanical exhibits of interest may be mentioned, Mr. Paget's blocks and winch, described and illustrated in another part of our columns. Railway brakes are represented by Mr. Naylor's continuous brake, which consists of a series of lever brakes kept out of action by means of a chain attached to the end of a lever, running the whole length of the train and hauled taut so as to elevate the end of such lever. If it be required to apply the brakes the chain is slackened, when the lever falls and a spiral spring actuating a knuckle joint presses the brake blocks against the wheels. Should by any means an accident occur such as a carriage breaking loose or running off the line, the chain would of course be broken, when the break would be immediately applied by the end of the lever dropping down and bringing into action the power of the spiral spring.

There is also a scheme exhibited by Mr. Barker, for working the brakes by means of hydraulic cylinders, but unless some liquid could be employed not liable to freeze, it would not be adapted for this country.

FIG. 1.

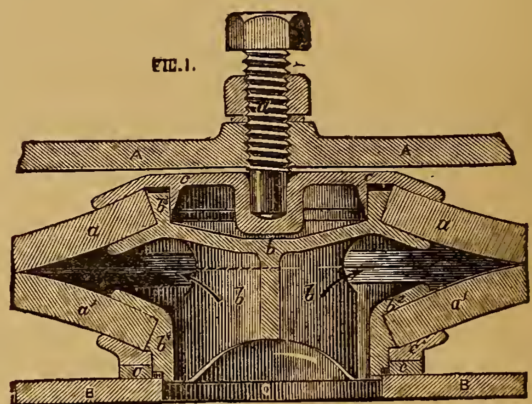


FIG. 2.

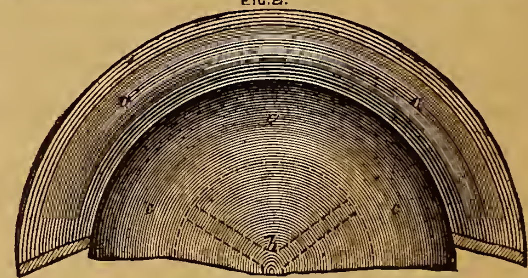
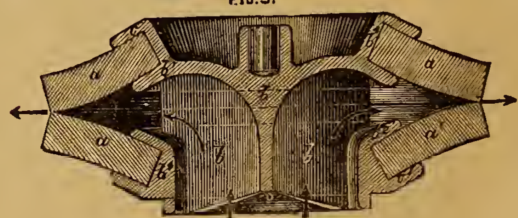


FIG. 3.



A very simple description of valve, termed a "disc-lip valve," invented by Mr. Field, was exhibited by Messrs. A. Wilson and Co., of Vauxhall Iron Works, and is illustrated in the accompanying engravings.

These valves are each composed of two india-rubber discs placed face to face, figs. 1 and 2 shewing the method of mounting these discs for very high pressures, and fig. 3 representing an alternative plan for lower pressures.

In figs. 1 and 2 the main body or casting b is provided with ledges and abutments b^1, b^2, b^3 and b^4, against which the elastic valves a and a^1 are held by the cover-plates c and c^1. The elastic discs a and a^1 are made quite flat, with central holes in them, and they are forced into and compelled to retain the conical form by being compressed and held by their inner edges as shewn. The outer edges of the discs abut against each other, and are forced together by the pressure of the water upon

their external surfaces. The casting on which the discs are mounted is held down in its place by the screw *d*, a ring of leather or india-rubber *o* being nsed to make a tight joint round the opening *C*, which the valve closes.

The simplified arrangement shewn in fig. 3 is for pressnres np to about 70 lbs per square inch. In this case the discs a a^1 are stretched so as to get them into the grooves between the flanges b^1 and c^1 and b^2 and c^2 respectively, no loose cover-plates being used.

In some cases the valves are arranged with only one elastic disc, which bears against a fixed seat.

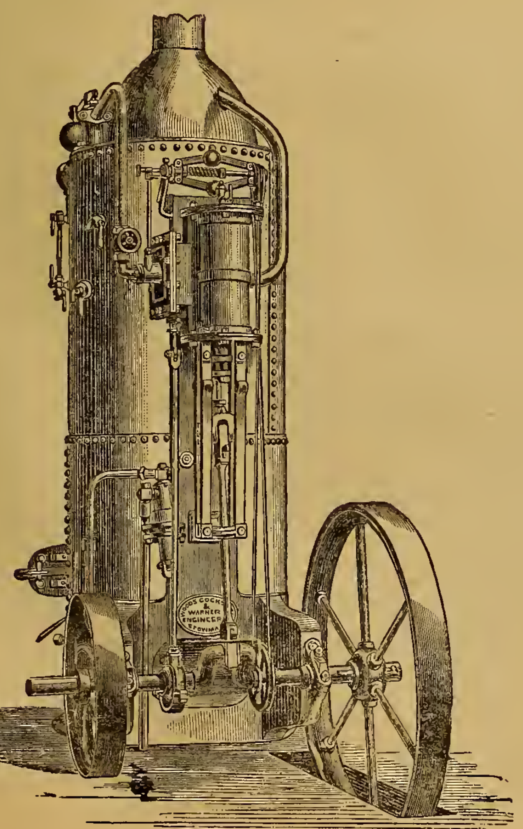
We hope to give further details of this conversazione in our next.

BATH AND WEST OF ENGLAND AGRICULTURAL SHOW.

The annual meeting of this Society was held this year at Guildford, on the 29th and two following days of May. As usual with these shows, the same implements and machines, or at least the same in appearance, are such regular attendants that little can be discovered that has not already been described. Thus the water supply was obtained from the neighbouring river by means of Messrs. Hayward Tyler, and Co.'s well-known "Universal" pump; which had been previously employed for the same purpose at the Oxford show last year. Nearly all the well-known agricnltural engineers were, as usual, well represented.

Amongst the few variations we have not beforc noticed, may be mentioned an important improvement in trussing the frames of thrashing machines, in order to prevent their sagging. It is well known that in consequencc of the frout and hind wheels of a portable thrashing machine being a long distance apart the framing is very liable to sag down in the middle, after having been workcd for a short timc, thereby disturbing the "truth" of the machinery, and proportionately increasing the wear and tear of the various parts, besides causing an nnnecessary amonnt of friction and consequeut loss of power. By the introduction of an iron diagonal truss of half-round iron, bolted to the inner side of the frame, and so arranged as to take its bearings directly over the axles, sufficient stiffness is obtained in a very simple manner.

We also noticed a very nice arrangement of an upright engine and



boiler, manufactured by Messrs. Woods, Cocksedge and Warner, Suffolk Iron Works, Stowmarket, which we illustrate in the accompanying engraving. The governor, which is npon the high spced principle, appears very simple and good, and doubtless, as all high-speed governors are very, sensitive; although as the engine was not at work, we could not obtain ocular demonstration of the fact. The pump, which is workcd off the same eccentric as the slide valve, is fitted with gun-metal ball valves, and check-feed valve to enable the snction and delivery to be examined while the steam is up. The engines with the exccption of those of only two or three horse power, are fitted on a cast-iron bcd plate, which takes the strain of all the working parts entirely, independautly of the boiler. This, we considcr, to be a great improvement upon the old plan of making the shell of the boiler serve as the engine framing. It is scarcely fair to make thc boiler serve for two distinct pnrposes, and unless the platcs are of extra thickness it is not safe; besides which, the expansion and contraction of the shell of the boilcr mnst interfere with the truth of the working parts of the engine.

REVIEWS AND NOTICES OF NEW BOOKS.

A concise view of the law connected with Letters Patent for Inventions. By JAMES JOHNSON, Barrister-at-Law, and J. HENRY JOHNSON, Assoc. Inst. C.E, London: Longmans, Green and Co., 1871.

In this exceedingly bricf pamphlet, we find a categorical statemeut of various processes requircd in the application of the Lettcrs Patent, together with some slight explanations. The authors, however, account for this, by referring "those persons who desire to investigate the details of this branch of the law" to their largcr work on the same subject, to which we prcsnme, this is intended to be an introduction.

The Technical Educator; An Encyclopædia of Technical Education, Vol. 1. London: Cassell, Petter and Galpin, Lndgate Hill, and 596 Broadway, New York.

Takcn as a whole, the volume now before us, undoubtedly snpplies a great want, and one which though long existing, has only comparatively recently been correctly estimated. From the rapid progress made during the prcsent century in all the arts of war and peace, it becomes more and more essential, that every man should have some knowledge of the gencral principles which govern the varions indnstrial processes, and of the modes of practically applying thcm. In the form in which this information is supplied by Messrs. Cassell, it loses much of that character of "dryness" which has tended to hinder non-professional readers from pernsing works of a purely scientific and philosophical character. By reading thc various articles as they appeared originally in numbers and at intervals, a vast amount of general knowledge is to be acquired in a very easy way, and during short intervals of time, which would othcrwise bc actually wasted simply for want of something to do, and the volume forms a convenient work for snbseqnent reference. The heavier reading is relieved by biographical notices, &c.

We cannot rccommend the work to professional stndents, except in the same way as to the pnblic at large as imparting a general idea of all the sciences. For instance, under the head "Mechanical Principles of Bridges," "the girder" wc find no formulæ except for solid rectangular beams, the Warren girder and all the rest being ignored; under the heads of "Thc Wooden Bridge," and "The Arch," there are no formulæ at all. The articles on mechanical drawing are very good. Thc articles on "water works" under the hcad of "Civil Engineering," are purely descriptive. On page 410, a very poor idea of the geueral class of helves now used is given, as they are actuated generally at the head *not the tail* of the hammer. Page 412, it is stated that the ingots of steel made for rails are taken direct from the ingot monlds, and passed to the mill at once; but such is not the case, as they are far two largc to enter the rolls. They are first drawn down under a steam hammer to enable them to euter the first rolls.

While pointing out to the engineering student these defects and omissions, we do it that he may not be misled by our expressing our opinion, that the work is most valuable to general readers, and that there should be a copy of it in every house where youths are growing up, as in addition to the information it gives, it may serve a still greater end, in stimulating somc to undertake further researches in some field of sciencc.

NOTES AND NOVELTIES.

MISCELLANEOUS.

The administration of the Messageries Maritimes—styled up to September, 1870, the Messageries Impériales—has reduced the first-class fare from Madras to Marseilles to 600 rupees. As the steamers of the line pass through the Suez canal, there is no railway fare to pay across the Isthmus of Suez.

M. J. F. Cail, head of the house of Cail and Co., whose death has just been announced, was a man of extraordinary activity and energy. He had risen from the rank of a workman to one of the highest commercial positions in France. The fatigue he endured during the siege of Paris first affected his health, and he was but sixty-seven years of age at the time of his death.

On the 2nd ult., Mr. T. S. Johnston's steam omnibus *Pioneer* commenced to run between Edinburgh and Portobello for the conveyance of passengers. It started and went at the speed of an ordinary coach from the foot of Waterloo-place in Edinburgh, and from John-street, Portobello; and although the hours at which it left these places for either of its destinations could not be previously announced on this its first day's running, it was well patronised, and quite filled at every trip. In order to give the passengers as much comfort as possible, their number is limited to forty—twenty inside and twenty outside. Very few of the horses that had to pass the omnibus seemed to be in any way frightened, with one or two exceptions in the case of horses unaccustomed to town traffic.

We understand that the iron shipbuilding yard, belonging to the sequestrated estate of Messrs. M'Culloch, Patterson and Co., Port-Glasgow, with plant, &c., was privately purchased on the 12th ult. by Messrs. Blair and Auld, for a client, at the sum of £7,000.

The labours of the Royal Commission on coal, appointed a few years ago by Sir George Grey, are on the point of completion, and the result is the demonstration of the fact that, assuming a certain annual increase in the rate of consumption, sufficiently economically gettable coal exists in Great Britain and Ireland to last from 800 to 1,000 years.

Mr. J. H. Cooper says, in the *Journal of the Franklin Institute*, "A good adhesive for leather belts is printer's ink. I have the case of a six inch belt running dry and smooth and slipping, which was entirely prevented for a year by one application of the above."

Experiments were lately made at the Denver gasworks, U.S., with Wyoming petroleum shale. Five hundred pounds were placed in a retort, and gas was generated in twenty-three minutes. In thirty-five minutes five hundred feet of gas were made. Another experiment was tried at a later hour with equally good results. This shale will probably prove an important source of gas for the Far West.

The American Government is about to erect an iron lighthouse of the first order, at South-West Pass, mouth of the Mississippi, State of Louisiana.

The provincial assembly of the province of Parana has passed a Bill for the establishment of steam navigation on the Iguapu. This is a river which falls into the Plate.

Here is a new use for snakes, for, although Aztec drum-heads were made of snake skins, the scaly material has never until now been fitted for the manipulations of the *cordonnier*. The statement is now current that a Boston firm last year tanned fifty anaconda skins for boot leather. The boots are valued at 50dols. a pair. The largest of these skins was forty feet in length. The tanning processes were similar to those in the manufacture of alligator leather, the product being a very beautiful and highly finished quality of leather, glossy, mottled, pliable, and exceedingly durable.

TELEGRAPHIC ENGINEERING.

The Anglo-American Telegraph Company on the 20th ult. received a telegram from their superintendent at Valentia announcing the repair of the 1865 cable. Both the cables of the company are now in working order.

STEAMSHIPPING.

On the 17th ult. the *King Orry* a new steamer, built by Messrs. R. Duncan and Co., Port-Glasgow, and engined by Messrs. Rankin and Blackmore, Greenock, for the Isle of Man Steam Packet Co., proceeded to Gareloch to have her compasses adjusted.

SHIPBUILDING.

A prospectus has been issued of the Thames Shipbuilding, Graving Docks, and Iron Works Company (Limited), with a capital of £250,000 in shares of £20, to take over the business of the Thames Ironworks, Shipbuilding, Engineering, and Dry Dock Company (Limited), "known as the greatest private shipbuilding establishment in this country."

LAUNCHES.

On the 15th ult., a twin-screw steamer of 500 tons was launched from the building yard of Messrs. T. B. Seath and Co., Rutherglen. The wife of Capt. Elkingham named the vessel *Mari V.* She is sister ship of several others constructing by the same firm for special service on the Danube. The dimensions are 175 by 27, and the machinery is on the compound principle, and supplied by A Campbell and Sons, Glasgow.

Mr. J. G. Lawrie launched on the 17th ult., at Whiteinch, a screw steamer of 900 tons for the Aberdeen, Leith and Clyde Shipping Company. This steamer is fitted up specially for passengers, having every modern convenience adapted for that trade. On leaving the ways she was named *St. Nicholas*, by the lady of Capt. Angus.

There was launched on the 19th ult. from the shipbuilding yard of Messrs. A. and J. Inglis, at Pointhouse, a paddle steamer for the Drogheda Steam Packet Company, named the *Lord Athlumney*. The principal dimensions are:—Length, 240ft.; breadth, 32ft.; depth, 16ft.; builders' measurement, 1,148 tons. This vessel is fitted with all the recent improvements, including steam winches, &c., and is intended for the Drogheda and Liverpool trade. The three decks are well fitted up for the safe conveyance of cattle, of which she will carry 500 head. There is also a turtle-back deck, extending the length of the main deck, for the protection of cattle in stormy weather. The vessel is also fitted with a handsome cabin underneath the quarterdeck, capable of accommodating 50 first-class passengers. The most noticeable feature, however, in the construction of the *Lord Athlumney* is the machinery, which consists of a single compound diagonal engine of 1,400 indicated H.P. This is the first steamer in the Channel trade fitted with the single compound engine, which causes this vessel to be looked forward to with a great amount of interest by shipbuilders and others connected with the trade. The *Lord Athlumney* is classed 18 years in the Liverpool Underwriters' registry for iron vessels. The ceremony of naming the vessel was performed by Mrs Branigan, wife of the captain.

There was launched from the building-yard of Messrs. John Reid and Co., shipbuilders, Greenock Road on the 6th ult., a symmetrical and substantially built iron sailing vessel. The ship, which was named the *Colmonell*, is the property of Mr. Kerr, of the estate in Ayrshire after which the vessel is called. The *Colmonell* is intended for the East India sugar trade, and has a carrying capacity of 1,200 tons. The *Colmonell* is the first of three similar vessels that are being built by the firm of Reid and Co. for the same owner. The ceremony of naming was gracefully performed by Miss Kerr.

On the 20th ult., Messrs. John Elder and Co., launched from their shipbuilding yard at Fairfield, Govan, an iron screw steamship of 3,850 gross tonnage, and 550 horse-power nominal for the Pacific Steam Navigation Company, of Liverpool. The vessel has been designed and constructed for that company's fortnightly service between Liverpool and Valparaiso, *via* Straits of Magellan, and is of the following dimensions:—Length between perpendiculars 370ft., breadth 41ft., depth moulded to spar deck 36ft. 9in. In the equipment of the ship, the latest improvements have been introduced, her internal arrangements, state rooms, saloon, &c., being fitted up and furnished in the highest style of elegance and comfort, having accommodation for 140 first class, 40 second class, and 800 third class passengers if required. The engines which are being supplied by the same company, are upon their compound principle with all recent improvements. The ceremony of naming the *Chimborazo* was gracefully performed by Miss Ross. The firm have other nine vessels on hands for the same company, viz.:—The *Cuzco, Aconcagua, Santiago, Truxello, Ilo, Sorata, Illimani, Cotopaxi*, and *Tacora*. The *Chimborazo* is similar in construction to the *John Elder*, launched from the same yard in August last.

TRIAL TRIPS.

One of the *Staunch* class of gun-vessels, the *Mastiff*, recently built for the Government at Jarrow, and fitted with engines by Messrs. Ravenhill, has lately concluded her speed trials over the measured mile in Stokes Bay, under the supervision of the officers of Portsmouth Dockyard factory and steam reserve. The *Mastiff* is 245 tons measurement, and is fitted with engines of 25 collective (nominal) H.P., driving twin screws. Her armament consists of one 18 ton M.L.R. gun, mounted with its carriage and slide on a lowering and rising platform. The little vessel's draught of water, being at her load line, was 5ft. 9in. forward and 6ft. 3in. aft. The wind was from the N.E. at a force of four. Water smooth. Six runs over the mile gave the vessel a mean of 8·297 knots per hour. Revolutions of the engines—starboard engines, per minute, 154·59; per mile, 1,124·6; port engines, per minute, 157·70; per mile, 1,147·3; collective indicated H.P., 232·99. The trial was considered very satisfactory.

On the 9th ult. the S.S. *Thames* went down the river on trial. This vessel has been built by Messrs. Archd. M'Millan and Sons, Dumbarton, for Messrs. Temperly, Carten, and Darke, of London, and is handsomely fitted up for 30 first and 400 steerage passengers. The engines, of 180 H.P., constructed by Messrs. John and James Thomson, worked with great smoothness, the vessel attaining a speed of 11 knots per hour with 1,000 tons dead weight on board.

The screw-steamer *Dagupan*, built to the order of a London firm by Messrs. Alexander Stephen and Sons, shipbuilders, Linthouse, and engined by Messrs. William King and Co., Dock Engine and Boiler Works, went down the river on the 16th ult. on her official trial, and, after adjusting compasses on the Gareloch, proceeded on her voyage to Manilla, being specially built to carry a large cargo on a light draught of water for coast and river traffic there. The machinery worked well, and she attained a speed of over nine knots with full cargo on board, being 1½ knot above the guarantee.

RAILWAYS.

There are in the United States forty-eight manufactories of railway-cars.

A line of railway, 30 miles in length, has been contracted for in Missouri for £53,000. This amount includes £3,300 for culverts, bridges, &c.

A railroad of 30in. gauge, eleven miles in length, is to be constructed in Green County, Tenn. It will cost 20,000 dols. only.

Since the commencement of the Union and Central Pacific Railroads, the population of San Francisco has increased from 60,000 to 150,000. The authorities of the Central Pacific line estimate the earnings of their road in 1871 at 10,000,000 dols.; and those of the Union Pacific line are estimated at 9,000,000 dols.

A select committee of the House of Commons has passed the preamble of the Somerset and Dorset Railway Bill, the subject of which is to establish complete narrow gauge communication between the west and the midland counties, and the North of England by the construction of a line from Evercreech to the Midland Railway at Bath, with a branch to the Bristol and North Somerset Railway at Radstock. It is understood that opposition will be continued to the Bill in the House of Lords.

The Metropolitan Board of Works, at their meeting on May the 26th resolved to contribute to the new street from Tottenham Court-road to Charing Cross, a sum not exceeding £200,000. The board believe the making of the railway from Euston square to Charing Cross creates a favourable opportunity for effecting a public improvement which has been urged for thirty years.

Mr. G. W. Pearsons writes to the *Scientific American*, on wooden railroads as follows:—"On the Clifton Railroad, I understand, they are principally maple. This wood is not so durable as oak in resisting decay, but wears far better under a wheel. The reputation which the Clifton road bears here among those best acquainted with it, and uninterested in it, seems to be quite similar to that of Messrs. Speer with theirs, so far as its permanent value is considered. The Messrs. Speer found their road wearing out very fast until they put iron on their wooden rails, thus virtually making a 'strap rail' road of it. So we travel over the old ground."

A change of gauge on the Cincinnati, Louisville, and Lexington Railroad will be made immediately from 4½ft. to 5ft., to correspond with the gauge of its northern connections. This makes the Northern and Southern lines terminal at Louisville instead of Cincinnati. When the Newport Bridge is completed through cars will run from Louisville, *via* the short line, to New York and all points east.

The report of the Scinde, Punjab, and Delhi directors states that the gross receipts show an increase of £63,090, and the net revenue an increase of £24,673. Those results are partly due to increased mileage. The opening of the Sutlej Bridge was too late to influence the results of the past half-year's working to any great extent; but now that the whole of the company's system has been placed in direct connection with the East India Railway, and unbroken railway communication has been established between Lahore and Mooltan and Delhi, Calcutta, and Bombay, an addition to the traffic may be looked for. The number of passengers conveyed by the company during the past half-year was 903,400, as compared with 732,610 in the same half in 1869. Of the total number carried 900,298 travelled by railway, and 3,102 by the vessels of the flotilla. The traffic was conducted without accident to any passenger.

A Select Committee of the House of Commons on the 22nd ult., pass the preamble of a Bill for creating a great central Metropolitan Railway Terminus between the Holborn Viaduct and the Farringdon-road Station. The South-Eastern, Chatham and Dover, South-Western, Great Western, London and North-Western, Midland, Great Northern, and Great Eastern Companies are all interested in this project.

The Mansion-house Railway Station.—Nearly 1,200 men are employed upon the station in progress near the end of New Earl-street, Cannon-street, and the approach to it from Blackfriars. Relays of men are employed and kept at work night and day. It is confidently expected, that this large portion of the District line will be opened for traffic on the 3rd inst. The works are already in such a forward state as to admit of trains being run through from Blackfriars, and a short time age Mr. Gladstone, Mr. Glyn, M.P., with Mr. Fowler, engineer, Mr. Baker, engineer, Mr. Myles Fenton, of the Metropolitan, and other gentlemen, passed over the line in an ordinary train. The entrance to the booking offices will be from the short frontage to Cannon-street, between New Earl-street and Bow-lane. The end of the station runs up to the top of Garlick-hill, the nearest platform, about 25ft. below the street level, being about 40 yards from Cannon-street. When completed, the station will have three double platforms, planked, 350ft. long by 15ft. broad, with one single platform. There will be a cross platform also at the end of the lines, giving access to the longitudinal platforms. The station-inspector's office and a refreshment buffet will open this platform, the dimensions of which will be width of the station, 63ft. in one direction and 45ft. in the other. The platforms will be covered by umbrella roofs of iron, filled in with glass for the whole depth. This final section of the District line, which is only about 25 chains in length, has involved an immense amount of labour, as may be inferred from the facts that in the last three months 150,000 tons of material have been taken off, and 50,000 tons of material have been brought to the ground. The station roofs and the works near the station will take about 1,000 tons of iron and steel. The new station, although entering from Cannon-street, will be designated the Mansion-house Station, as a second Cannon-street Station would have been inconvenient; and it is, besides, within sight and a short distance of the Mansion-house, the Royal Exchange, and the Bank. This extension will be the terminus of the District system, and an end, for the present, of the idea of an inner circuit. The circuit, it it is ever to be joined up, must be by a shorter and less costly route than by the abandoned portion of the District line, and the authorized portion of the Metropolitan line—to which that compauy is held bound by Parliament—that were to have met at Tower-hill.

TRAMWAYS.

The Scottish Steam Cultivation and Traction Company have commenced operations. Stations are at once to be supplied at the Carse of Gowrie, the Carse of Stirling, and for Roxburghshire. Further wide extensions of the system are under consideration.

A commencement has been made of the works in conection with the system of tramways to be constructed in the principal thoroughfares in Leeds. The tramway from the bottom of Park-row to Headingley is to be laid down first, and the ground was broken last week on that portion of the route which crosses Woodhouse Moor. The contractors began at the Leeds end of the Moor, on the south side of the highway, and they are working towards Headingley.

A special meeting of the Pimlico, Peckham, &c., Tramways Company was held on the 9th ult., at the offices in Parliament-street, Mr. Evans in the chair, when a resolution was passed approving a bill now before Parliament for authorising the London Tramways Company to construct additional tramways in the counties of Middlesex and Surrey, and in the city of London, and for other purposes. Subsequently a meeting of the Metropolitan Tramways Company was held at the same office, Mr. Evans in the chair, when the same formal resolution was agreed to.

DOCKS, HARBOURS, BRIDGES.

A company has been organised at Fort Madison, Iowa, for the purpose of building a suspension bridge across the Mississippi at that point. The capital stock of the company is to be 1,200,000 dols.

The formal test of the new Keokuk Bridge over the Mississippi was made on the 18th May by bringing five locomotives of the Des Moines Valley Railroad to a halt on each span and running them all together over the bridge bore the tests satisfactory

For some years past efforts have been made to induce the Thames Conservators to sanction the construction of a lock on the Thames near Richmond. Another memorial on the subject has recently been presented to the Conservancy Board by the local authorities of Richmond, Twickenham, Teddington, Brentford, Isleworth, Petersham, Ham, &c. The memorialists draw attention to the alarming increase in the quantity of mud in the district, to the nuisance arising thereform at low tide, and to the consequent depreciation of property in the neighbourhood, as well as to the inconvenience caused to boating, fishing, and excursion parties. The conservators have promised to take the subject into consideration and to forward a reply to the memorial.

The St. Thomas Dock Company (Limited) have invited subscriptions for £25,000. 10 per cent. debentures (in addition to the previous issue of £30,000), redeemable in ten years, the amount being mainly required for repairing and putting to work the large iron dock which was sunk when on the eve of completion in the Harbour of St. Thomas, in the West Indies, and which has been lately raised and transported to a place of safety, where it now awaits the necessary repairs. The dock haa cost more than £100,000, and Mr. Penn, has declared that it will fully answer the intended purpose.

APPLIED CHEMISTRY.

M. E. Becquerel has shown that the electric spark may be diversely aud beautifully coloured by being made to pass through saline solutions. If an electrical spark from an inductive apparatus be made to pass into the extremity of a platinum wire suspended over the surface of the solution of a salt, this spark will acquire special colouration according to the chemical composition of the solution traversed. The saline solutions are best concentrated, and the platinum wire positive. The experiment is readily performed in a glass tube. Salts of strontia will colour the spark red; chloride of sodium, yellow; chloride of copper, bluish green, &c. The light from these sparks, analysed by the spectroscope, furnishes a method for the determination of the nature of the salts contained in the solution.

It it stated that the hydrate of chloral can be employed as a reducing agent to great advantage. All of the noble metals are at once reduced by it, in the presence of caustic potash or soda; and as chloroform is evolved in the process, and this envelopes the reduced powder, the precipitate can be readily washed out. When the solutions of gold, or of the metals of the platinum group, are treated with hydrate of chloral, warmed, and an excess of caustic soda added, and the whole boiled for a minute, a complete reduction of the metals takes place, probably in consequence of the formation of some formic acid, by the splitting up of the chloroform. In the case of silver salts the reduction is also complete, and chloride of silver is formed. Mercury salts are not acted upon. These properties of the hydrate of chloral suggest its possible application for metal plating on glass, and possibly in photography.

A cement which becomes excessively hard in time may be prepared by mixing two parts of silica, one part of silicate of alumina, and nine or ten parts of carbonate of lime, all in powder, and then roasting in a puddling furnace. The remaining mass is then to be ground and again roasted with two or three parts of carbonate of baryta. In practice, very pure sand will answer for the silica and chalk for the carbonate of lime, the remaining ingredients being supplied by mineral witherite or natural carbonate of baryta.

LATEST PRICES IN THE LONDON METAL MARKET.

	From			To		
	£	s.	d.	£	s.	d.
COPPER.						
Best selected, per ton	76	0	0	„	„	„
Tough cake and tile do.	74	0	0	„	„	„
Sheathing and sheets do.	77	0	0	79	0	0
Bolts do.	79	0	0	„	„	„
Bottoms do.	82	0	0	83	0	0
Old do.	60	0	0	„	„	„
Burra Burra do.	76	0	0	„	„	„
Wire, per lb.	0	0	9¾	0	0	10
Tubes do.	0	0	10½	0	0	10¾
BRASS.						
Sheets, per lb.	0	0	8	0	0	9
Wire do.	0	0	7¾	„	„	„
Tubes do.	0	0	8	0	0	10½
Yellow metal sheathing do.	0	0	6¾	0	0	7¼
Sheets do.	0	0	6½	0	0	6⅝
SPELTER.						
Foreign on the spot, per ton.	18	5	0	18	10	0
Do. to arrive.	18	10	0	„	„	„
ZINC.						
In sheets, per ton	24	10	0	„	„	„
TIN.						
English blocks, per ton.	132	0	0	„	„	„
Do. bars (in barrels) do.	133	0	0	„	„	„
Do. refined do.	136	0	0	„	„	„
Banca do.	132	0	0	133	0	0
Straits do.	131	0	0	132	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	8	6	1	9	0
IX. do. 1st quality do.	1	15	0	1	16	6
IC. do. 2nd quality do.	1	7	6	1	8	0
IX. do. 2nd quality do.	1	13	6	1	14	0
IC. Coke do.	1	4	0	1	5	0
IX. do. do.	1	10	0	1	11	0
Canada plates, per ton	13	10	0	15	0	0
Do. at works do.	13	10	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	10	0	„	„	„
Do. to arrive do.	7	7	6	7	10	0
Nail rods do.	7	10	0	7	15	0
Do. Stafford in London do.	7	12	6	8	0	0
Bars do. do.	8	0	0	9	2	6
Hoops do. do.	8	15	0	9	0	0
Bars do. at works do.	7	15	0	8	0	0
Hoops do. do.	8	2	6	8	5	0
Sheets, single, do.	9	7	6	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	6
Bars, common, do.	6	15	0	„	„	„
Do. mrch. Tyne or Tees do.	6	15	0	„	„	„
Do. railway, in Wales, do.	6	15	0	7	0	0
Do. Swedish in London do.	10	2	6	10	5	0
To arrive do.	9	17	6	10	5	0
Pig No. 1 in Clyde do.	2	17	0	3	2	0
Do. f.o.b. Tyne or Tees do.	2	9	6	„	„	„
Do. Nos. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	0	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	16	0	0
English spring do.	17	0	0	23	0	0
Quicksilver, per bottle	9	10	0	10	0	0
LEAD.						
English pig, common, per ton	18	0	0	18	2	6
Ditto L.B. do.	18	5	0	„	„	„
Do. W.B. do.	19	5	0	„	„	„
Do. sheet, do.	18	15	0	„	„	„
Do. red lead do.	20	10	0	„	„	„
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	20	10	0	„	„	„
Spanish do.	17	15	0	„	„	„

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

DATED MAY 9th, 1871.

1253 J. Craik and W. Balshaw—Looms
1254 R. Suggitt, T. Court, and R. Court—Winding machines
1255 S. B. Allen—Governor

DATED MAY 10th, 1871.

1256 J. J. Seekings—Bolts, &c.
1257 F. A. Paget—Springs
1258 W. H. and E. B. Edwards—Watering roads, &c.
1259 St. John V. Day—Engines
1260 D. and P. Forbes—Wringing machines
1261 C. Brocklehurst—Drawing silk
1262 A. P. Dickinson—Preparation of yarn
1263 A. V. Newton—Facilitating payment
1264 W. Holland—Clipping horses

DATED MAY 11th, 1871.

1265 R. Bourne—Navigation
1266 D. Nickols—Taps, &c.
1267 A. Wallis and C. J. Stevens—Stacking hay
1268 W. Firth—Tyres
1269 F. J. Fahlman—Disinfecting
1270 W. H. Thompson—Motive power
1271 A. M. Clark—Cofferdams
1272 G. W. Bacon—Washing fabrics
1273 H. O. Bennett—Applying steam
1274 W. Walkington—Tool holder
1275 R. L. Jones—Clocks

DATED MAY 12th, 1871.

1276 E. Brooks and J. Fletcher—Manufacture of certain fabrics
1277 S. Brierley—Bleaching
1278 F. J. Cheesbrough—Flour
1279 J. Carpenter—Unloading hay
1280 B. W. Rogers—Bolt screwing machinery
1281 J. Tonkinson—Locks
1282 F. Kinnear and E. Martin—Flannel hands
1283 T. R. Shaw and S. Boardman—Lubricators
1284 S. Rogers—Shoes for horses
1285 J. and T. Kennau—Fences
1286 J. Kirk—Alarm apparatus
1287 J. Welch and C. Laight—Cases

DATED MAY 13th, 1871.

1288 F. Taylor—Paper collars
1289 W. Bayliss—Securing uprights
1290 T. Grant—Fuel
1291 J. T. H. Richardson—Lenses
1292 J. Hopkinson—Weighing machines
1293 J. Grindrod—Automatic boiler
1294 E. Barraclough and F. J. Bright—Looms
1295 A. H. Gilhody—Meat safes, &c.
1296 J. Whittaker—Untapped nuts
1297 G. Little and T. C. Eastwood—Combing machinery
1298 T., D., and W. Donvaband—Weighing machines
1299 W. H. Balmain—Soda prepared
1300 R. Ogilvie—Stuffing Boxes
1301 T. Green—Boilers

DATED MAY 15th, 1871.

1302 A. Donald and A. J. Atkey—Pulverising, &c.
1303 L. B. Bertram—Knife handle
1304 P. J. Livsey—Mirrors
1305 E. Königs—Treating pyrites
1306 H. Andrew—Stand for gloves
1307 D. C. E. Leloup—Hanging gates
1308 W. Jackson—Kilns
1309 J. Shackleton—Applying steam
1310 W. S. Laycock—Substitute for the 'oil hairs,' &c.
1311 W. J. Menzies—Treatment of phosphates
1312 J. Law and M. Bennison—Hoisting
1313 H. P. Hull—Cultivating the soil

DATED MAY 16th, 1871.

1314 J. Wilson—Sugar
1315 D. O. Macomher—Composition
1316 J. Southwood—Apparatus for receiving excrement
1317 J. Baker—Fastener for sashes
1318 W. Martin—Movable weirs
1319 H. Duncan—Pipes
1320 L. Blumfeld—Pipes, &c.
1321 W. Dawes—Steam engines
1322 W. Avery—Cases for needles
1323 W. R. Lake—Preventing incrustation
1324 J. F. Griffin—Reaping, &c.
1325 E. Pavy—Transporting passengers
1326 J. B. Muschamp—Explosive substance
1327 W. R. Lake—Steam engines

DATED MAY 17th, 1871.

1328 C. Broomhall—Locks
1329 J. Hayman—Rescuing from fire
1330 T. R. H. Fisken—Working helms
1331 C. D. Abel—Cotton gins
1332 B. Bloomfield—Cracking stones
1333 L. Stewart—Wheels
1334 W. Shackleton—Looms
1335 R. Wilson—Mangling, &c.

DATED MAY 18th, 1871.

1336 R. Patton—Pulp for paper
1337 H. Aitken and R. McAlley—Alum
1338 D. and J. Smith—Moulding
1339 W. E. Newton—Generating gas
1340 Marquis of Tweddale—Firearms
1341 J. G. Jennings—Receptacles for waste water
1342 W. F. Reynolds and J. A. Mays—Wheels, &c.

DATED MAY 19th, 1871.

1343 N. Brough—Fastenings for braces
1344 G. R. Hugon—Wire work
1345 W. Hick—Fastener for buttons
1346 C. A. Sperati—Signalling, &c.
1347 W. Galloway—Sewing machines
1348 E. Hunt—Stench traps
1349 T. von Bolzano—Grates
1350 J. R. Jefferies—Ploughs
1351 J. Turney—Scudding split skins
1352 A. M. Clark—Dressing leather
1353 W. E. Newton—Hulls of vessels
1354 A. V. Newton—Couplings
1355 W. R. Lake—Covering leather

DATED MAY 20th, 1871.

1356 G. Slater—Sewing machines
1357 H. Larkin, A. Leighton, and W. White—Bleaching powder
1358 J. Hopkinson—Steam engines
1359 N. Stokes—Improvements applicable to carriages
1360 W. Garnett—Saddles
1361 W. E. Newton—Electro-magnetic engines
1362 A. V. Newton—Hollow ware
1363 P. Rumine—Producing ozone
1364 A. G. Day—Insulating covering
1365 W. R. Lake—Nitro-glycerine
1366 C. Wigg—Cupreous ores

DATED MAY 22nd, 1871.

1367 G. Turner—Marquees
1368 W. Walker—Steam pumps
1369 R. Olpherts—Presses
1370 A. V. Newton—Railway carriage wheels
1371 J. McKay and W. Macgeorge—Punching machinery
1372 J. C. Ramsden—Looms
1373 J. Jones—Coffins
1374 A. M. Clark—Preparation of colors
1375 W. R. Lake—Paddle wheel

DATED MAY 23rd, 1871.

1376 G. Reinlein—Pump
1377 T. Southan—Shoe tips
1378 J. R. Johnson—Lubricating compounds
1379 L. Perkins—Wheels
1380 E. Taylor—Washing coal slack
1381 T. H. Granger and J. P. L. Hyan—Means to heat rooms
1382 S. P. Darwin—Gas
1383 Sir W. Mitchell and J. J. Mayo—Signal apparatus
1384 T. B. Ayshford—Dog carts
1385 J. Glover and A. Goodman—Bleaching powder
1386 St. John V. Day—Refining sugar
1387 J. H. Johnson—Transporting cargoes
1388 W. R. Lake—Disintegrating machinery
1389 J. S. Manton—Firearms

DATED MAY 24th, 1871.

1390 J. W. Smith—Fermenting worts
1391 B. H. Worrall—Supplying fuel
1392 R. P. Williams—Permanent way
1393 W. L. Anderson—Working guns
1394 H. Oliver—Polishing granite, &c.
1395 T. F. Cbappé—Valves
1396 A. M. Clark—Strainers, &c.
1397 P. Fleming—Brakes
1398 R. Whehle—Coverings for the head
1399 G. Haseltine—Carpet rods
1400 W. R. Lake—Printing telegraph
1401 A. Vansteenkiste and J. Barhe—Steam Boilers
1402 J. Meiklejon—Hoisting, &c.

DATED MAY 25th, 1871.

1403 A. Wright—Mustard pots, &c.
1404 G. Ritchie—Tents, &c.
1405 W. Laycock—Calico-printing machines
1406 R. Dawlings—Carbonised iron ore
1407 R. Clarke—Fans for blowing
1408 E. W. Pugin and J. W. Ayres—Fastening for doors
1409 W. A. Gilbee—Photography
1410 F. Curtis—Picking waste

DATED MAY 26th, 1871.

1411 A Tylor—Meters
1412 R. Burton and R. H. Shaw—Wheels
1413 J. Walker—Floorcloth
1414 W. Dickinson and W. Parkinson—Beaming yarn
1415 T. Oliver—Grinding corn
1416 B. E. K. Newlands—Alum
1417 A. A. and J. F. M. Pollock—Closets

DATED MAY 27th, 1871.

1418 H. E. Towle—Steam engines, &c.
1419 A. Nash—Loop fasteners
1420 C. Morfit—Treatment of phosphates of lime
1421 R. Green—Finishing felt hats
1422 A. V. Newton—Treating wood, &c.
1423 E. J. C. Welch—Filling steam boilers
1424 E. Price and C. Thomas—Clipping horses
1425 G. C. Wilson—Breech-loading firearms
1426 J. and J. Manuel—Self-acting lever
1427 J. Bowden—Felting hat bodies
1428 A. M. Clark—Battery gun

DATED MAY 29th, 1871.

1429 S. H. Musgrave—Delivering fluids
1430 W. C. Eyton—Grinding mills
1431 J. Dorrell and F. Rudge—Slabbing iron
1432 W. R. Lake—Lamps
1433 W. Palliser—Boots

DATED MAY 30th, 1871.

1434 R. Barker—Cleaning cotton
1435 H. B. Fox—Milk skimmer
1436 R. B. Lindsay—Packing
1437 J. Hickman—Signals
1438 C. F. Whitworth—Fastening gates
1439 H. W. Putnam—Bottle-stopper fastenings
1440 B. J. B. Mills—Constructing seals
1441 A. M. Clark—Eyelets

DATED MAY 31st, 1871.

1442 T. Hirst—Looms
1443 S. Elsner—Signal lamps
1444 W. R. Lake—Printing telegraphic apparatus
1445 T. H. Granger and J. P. L. Hyan—Carrying away the refuse from sewers
1446 M. Benson—Sewing machines
1447 S. Nicholls—Watering cart
1448 H. D. Plimsoll—Safety lamps
1449 G. Tangye—Snatch blocks
1450 J. H. Johnson—Heating
1451 A. B. Fleming, G. V. Turnhull, C. Salvesen, R. Irvine, and R. C. Maglagan Treatment of wool
1452 E. Silk and G. Wells—Charcoal box irons
1453 T. Sweeney—Fluid meter

DATED JUNE 1st, 1871.

1454 E. Crespi—Venetian blinds
1455 C. F. Chew—Pianofortes
1456 J. E. Ransome—Ploughing land
1457 The Hon. J. T. Fitzmaurice—Adjustable tables
1458 R. and J. Podmore—Cork-soled boots
1459 W. Crabb—Hat plush
1460 I. L. Pulvermacher—Magnetic chains
1461 W. Clay—Gas furnaces
1462 A. V. Newton—Cutting stone
1463 H. T. Tubbs—Cases for pins
1464 W. R. Lake—Blocks for colour printing
1465 T. English and G. Wilson—Bending armour plates
1466 H. Bessemer—Ordnance

DATED JUNE 2nd, 1871.

1467 P. Rnmine—Treatment of wines
1468 F. J. Noble and W. H. J. Grout—Bicycles
1469 A. Videky—Separating excrement
1470 R. W. Stewart—Washing yarns
1471 J. and A. Rothery—Cutting coal
1472 J. Dean and J. Orton—Cut nails
1473 E. O. Hayes—Boats
1474 W. R. Lake—Telegraphic printing
1475 B. Thompson—Peramhulators

DATED JUNE 3rd, 1871.

1476 M. A. Muir and J. McIlwhan—Looms
1477 F. R. Jones and A. Bell—Producing mechanical motion
1478 W. T. Tongue—Steaming apparatus
1479 E. Chadwick—Walls, &c.
1480 J. Turnock—Attemperators
1481 E. Clarke and J. Hughes—Safety cages
1482 T. Hyatt—Illuminating gratings
1483 W. Seed—Spinning cotton
1484 J. Gooderham—Lamp shades

DATED JUNE 5th, 1871.

1485 S. Whitaker—Cocks
1486 T. T. Blair—Compositions
1487 J. W. Burton—Treating oils
1488 J. E. and A. Dowson—Tramways
1489 B. Tanner—Phosphates
1490 R. M. Marchant—Manufacture of ice
1491 W. R. Lake—Harmoniums
1492 A. Teague—Nices
1493 J. Stephens—Ventilating hospitals
1494 T. Osborne—Railway brakes
1495 C. Sholl—Hammers
1496 R. Winder and T. Wood—Skifes

DATED JUNE 6th, 1871.

1497 H. Shaw—Retarding the wheels of railway carriages
1498 A. B. Blackburn—Pens
1499 J. M. Angellet—Burning oils
1500 J. M. Fisher—Protecting grain
1501 W. R. Lake—Journal boxes
1502 A. Sparrow—Metal ties
1503 W. R. Lake—Hoisting machines

DATED JUNE 7th 1871.

1504 W. Blunn and J. Wild—Fire grates
1505 J. Millward—Water indicator
1506 W. L. Granville—Turntable
1507 J. Broel—Punching designs
1508 A. Bradshaw—Printing calico, &c.
1509 W. R. Lake—Signal telegraphs
1510 W. R. Lake—Stamping

DATED JUNE 8th, 1871.

1511 H. Wilde—Boiler tubes
1512 J. S. Heath—Breech loading firearms
1513 J. Taylor and W. Cooke—Steam engines
1514 H. E. Hutchins—Locks and keys
1515 J. Bottomley and W. Haggis—Preparing wool, &c.
1516 H. R. Minns—Iron shutters
1517 W. and A. Pollock—Preparing cloth
1518 H. Larkin and W. White—Production of iron
1519 W. R. Lake—Pads for trusses
1520 W. R. Lake—Device for binding papers
1521 J. C. F. Lee—Tipping railway waggons
1522 T. Griffiths—Protecting metal surfaces
1523 W. R. Lake—Railway sleeping carriages
1524 W. R. Lake—Railway, hotel, and dining carriages
1525 R. C. Munsen—Lubricator

DATED JUNE 9th, 1871.

1526 B. A. Norris—Improved casket
1527 W. Clarke—Shoemakers' pincers
1528 J. Robertson—Turning, horing, &c.
1529 J. Aitken—Application of tallow, &c.
1530 W. Poupard and J. Thomson—Ventilating buildings
1531 C. Crockford—Production of alkalies
1532 J. Lister—Envelopes
1533 A. Crichton—Breech loading firearms
1534 W. Campbell—Lifeboats

DATED JUNE 10th, 1871.

1535 W. A. Lyttle—Voltaic hatteries
1536 S. H. Huntly—Cooking stoves

STEAM FLOATING FIRE ENGINE,

BY

MESSRS MERRYWEATHER & SONS, ENGINEERS, LONDON.

FIG. 1.

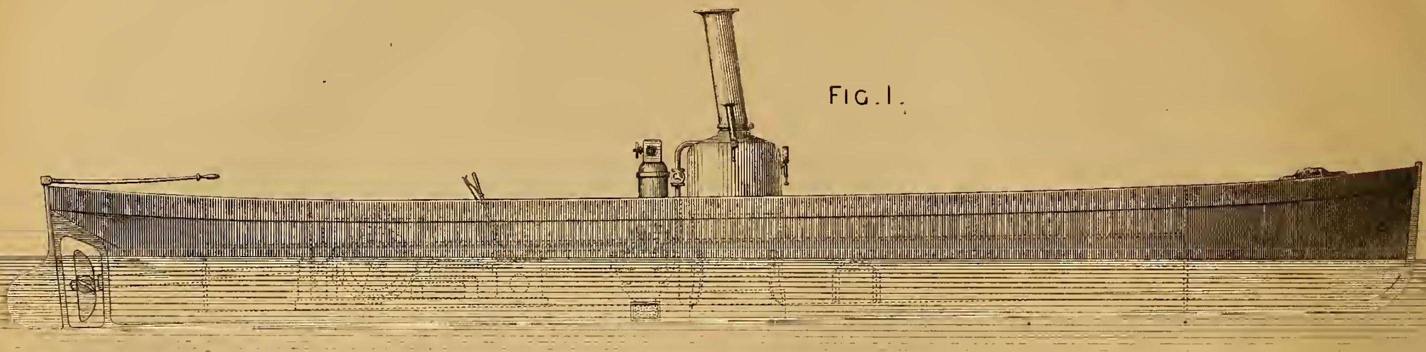
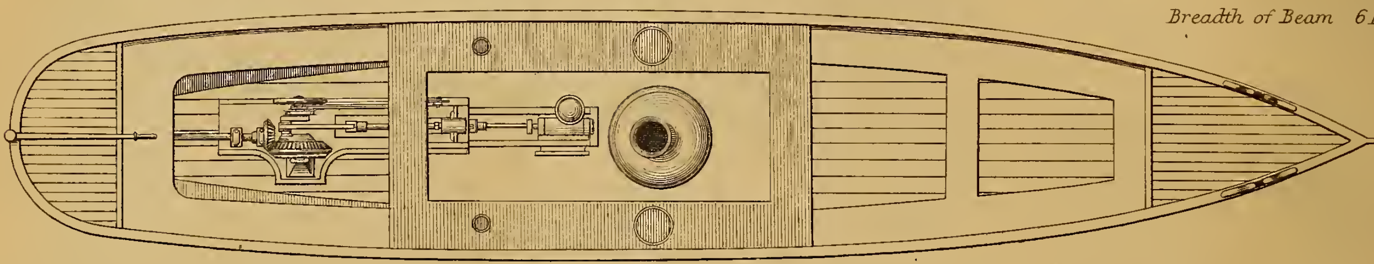
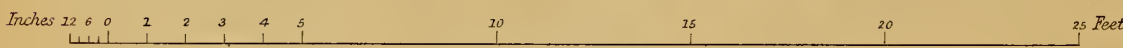


FIG. 2.

Length .... 35 *Feet*

Breadth of Beam 6 *Feet*





SCALE TO FIGS. 1 & 2

FIG. 3.

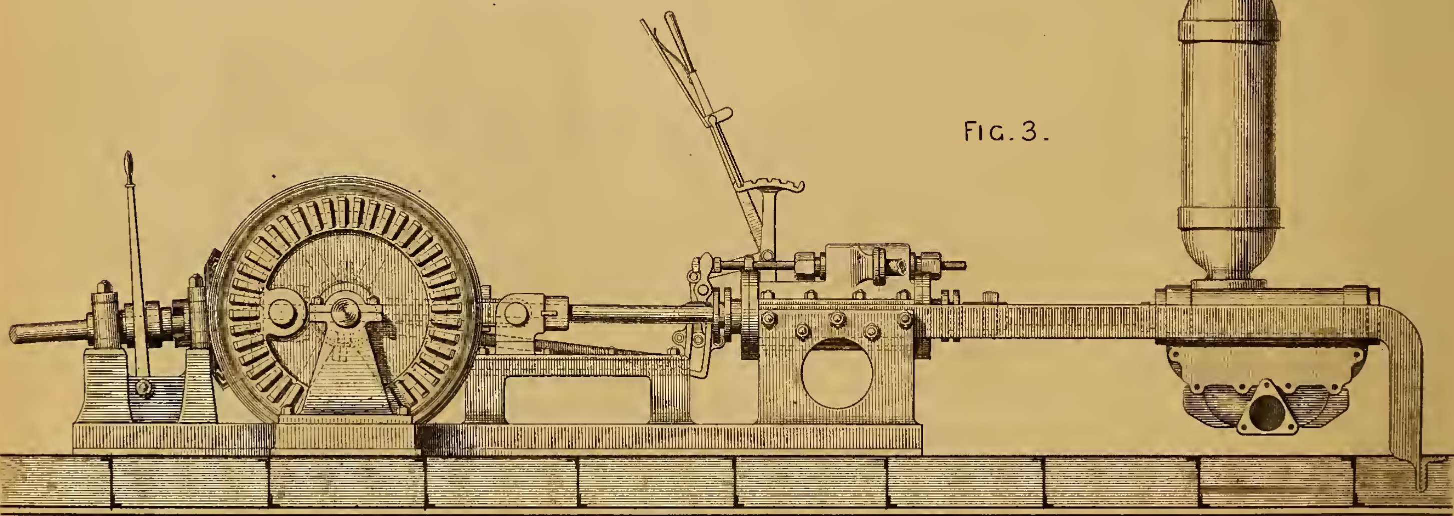
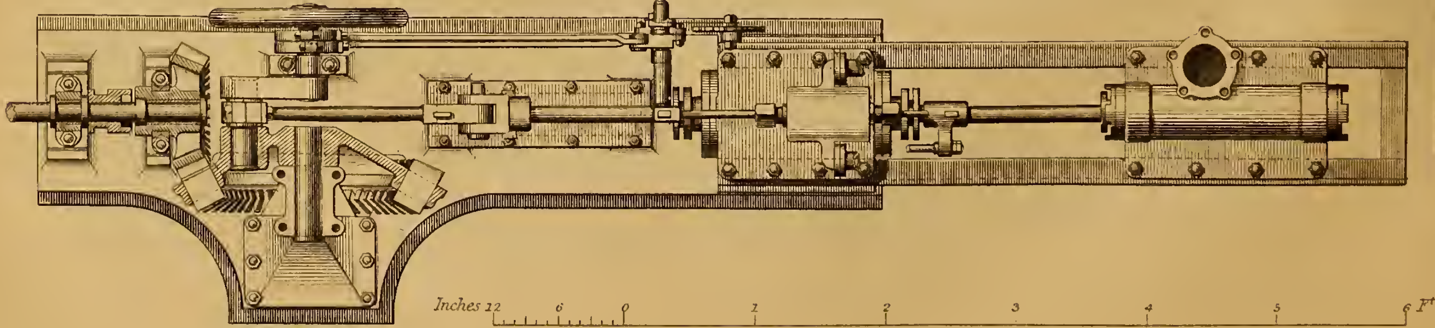


FIG. 4.



SCALE TO FIGS 3 & 4

P. Soames, A.K.C. delt. *G.B. Smith, sc.*

THE ARTIZAN.

No. 8.—Vol. V.—Fourth Series.—Vol. XXIX. From the Commencement.

1st AUGUST, 1871.

STEAM FLOATING FIRE ENGINE.

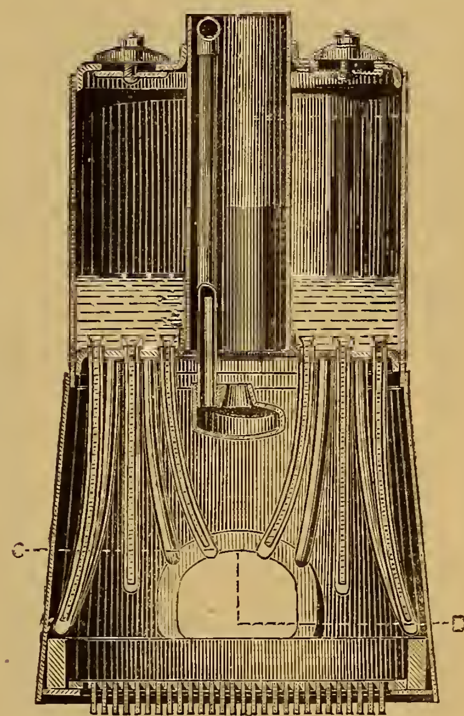
By Messrs. Merryweather and Sons.

(Illustrated by Plate 376).

In the accompanying Plate (376) we illustrate a steam floating fire-engine lately constrncted by the well-known firm of Messrs. Merryweather and Sons, of Long-acre, London, for the city of Venice. It has long been a matter of astonishment that so few of the numerous towns situated on the sea-side, or on the banks of navigable rivers, are provided with floating fire-engines. In towns thus situated the most valuable, and we may add the most combustible property is almost invariably to be found at the waterside, and yet in many instances there is not so much as a single fire-engine placed in the only position in which a conflagration could be successfully attacked. Many towns in the tropics, where, in consequence of the material with which the houses are built, combined with the intense heat of the sun, fires are both frequent and disastrous, are totally unprovided with any suitable means for extinguishing them. In some towns, as, for instance, in China and Siam a large proportion of the population not only live in houses near the water, but absolutely upon it, the only means of gaining access to which is by means of boats; hence when a fire occurs entire rows of houses are consumed, and the fire is rarely extinguished until it reaches some spot where the houses are too far distant to admit of the flames attacking them. For Venice, where the streets are composed of water, a floating fire-engine is peculiarly adapted, and we have no doubt that the engine we now illustrate will prove a most valuable addition to the safety of that city.

The launch in which the fire-engine is fitted is of iron, and is 35ft. long by 7ft. beam, and draws only two feet of water when completely equipped with boiler and machinery, coal, hose, and firemen. The diameter of the steam cylinder is 5½in., with a 12in. stroke, the pump, which is double acting, being 4½in. diameter, with the same length of stroke. The pump is all in one solid casting of gun metal, the barrel being placed above the water passages. The pump-valves are upon Mr. Field's principle, which was illustrated in The Artizan of last month (p. 164), and, besides the advantages there enumerated, they are found to work perfectly well with dirty or sandy water, in consequence, we presume, of the elasticity of the india-rubber of which they are composed. These valves are so arranged that as soon as the engine is stopped all the water runs out of the pump, thereby preventing any accident from freezing when in cold climates. The boiler may be fed either through the main pump, or when the water is salt by a separate feed-pump from the fresh water carried in tanks in the boat. There is also a Giffard injector attached to the boiler, which may be used in case of any accident happening to the feed-pump. The main pump is fitted with copper suction and delivery air vessels; it has also delivery outlets with stop valves screwed to receive the couplings, and a pressure gauge for indicating the force of water in the passages. The screw shaft is connected to the engine by means of bevil gearing, and is thrown in, or out of, gear by means of a clutch. The pump-rod is connected to the piston-rod of the engine by means of a cotter, and by these means the engine can be made to work either the screw or the pump, and if necessary both together.

The boiler, which is illustrated in the accompanying engravings, is on the "Field" principle, the external tubes being 1⅛in. in outside diameter, and the internal tubes ⅝in. iu diameter. There are 70 tubes 1ft. 7¼in.; 28 ditto, 1ft. 4in.; and 65 ditto, 1ft. 1¼in. in length; making a total of 163 tubes; the height of the boiler being ouly 3ft. 6¾in. The



speed of the boat on the trial was about 8 knots per hour, which, considering its dimensions and the small diameter of the cylinder, must be considered very good. The boat is provided with fresh-water tanks,

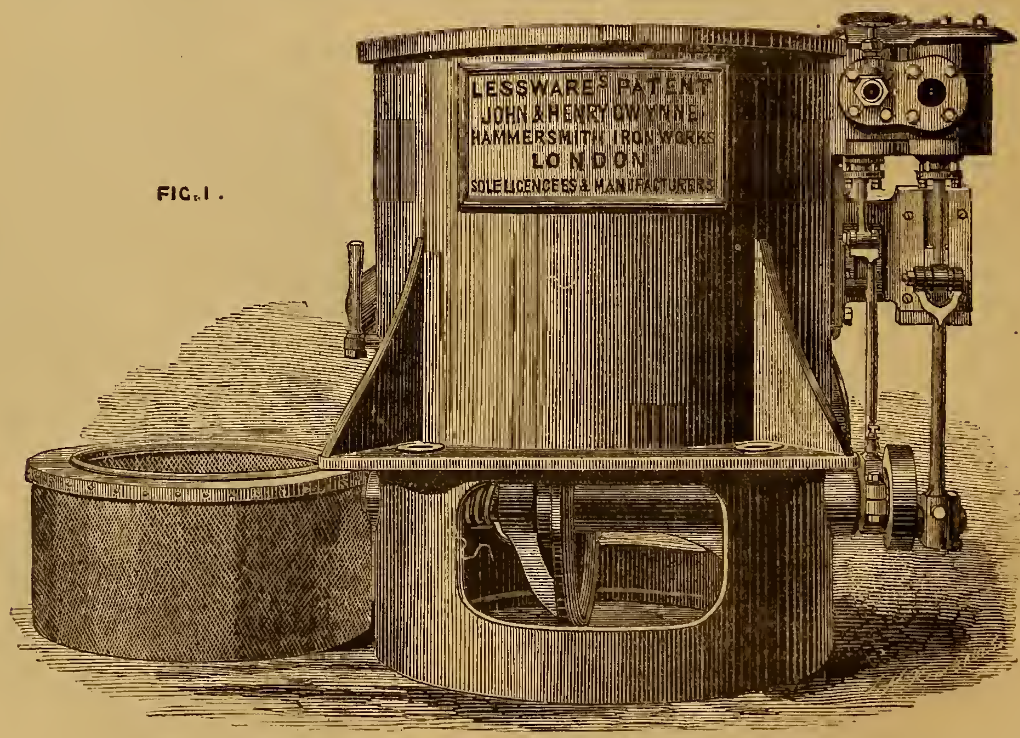
coal bunkers of sufficient capacity to hold 20 hours' consumption, and is also provided with large bunkers for storing the hose. Altogether we consider that Messrs. Merryweather have turned out a remarkably good specimen of a small floating fire-engine, and we shall be surprised if the demand for similar engines does not become extensive.

THE MANUFACTURE OF CANE SUGAR IN THE COLONIES.

(*Continued from page* 147.)

As we have already observed, the number of designs that have been proposed for centrifugal machinery have been very large. Most of these, however, are also very faulty, amongst which may be included, all those which have for their object the lessening the vibration by means of springs or india-rubber washers and bands. These latter systems appear to have been designed to meet the requirements of bad workmanship in the other parts of the machine. Thus, it is well known that when machinery has to be driven at a high velocity, the vibration will be excessive, if the various working parts are not perfectly true, or if the revolving parts are not correctly balanced; and it was, we believe, in consequence of the excessive vibration caused by the inattention to these vital points, that some makers endeavoured to mitigate the evil by having recourse to yielding materials. As soon, however, as the manufacture of centrifugals was taken up by first-class engineers, it was found that they would run at any required speed with scarcely any vibration, without any elastic appliances, provided the parts were sufficiently strong, and that they were firmly bolted down to a good foundation. In the illustrations previously given in The Artizan, it will be observed, as those which are driven from below. The advantage, moreover, of a top bearing is not so important as would at first sight appear, as the peculiar shape of the basket with a cone running up in the centre, admits of a bearing being placed sufficiently high up to prevent any undue strain upon the driving spindle. If this driving spindle be made of steel and fitted with sufficiently long bearings of white metal, we consider that it will last quite as long as in those which are driven from above. The system of driving from beneath the basket possesses many important advantages over the other. Thus, in filling the basket, which is usually done by means of buckets, the spindle of those centrifugals which are driven from above is very much in the way, and in the case of small machines, it becomes almost impossible to sufficiently invert the bucket of raw sugar without allowing some of its contents to run over the top into the casing; whereas in the case of those machines which are driven from below, no such impediment exists. Again, in order to carry the top bearing in the overhead machines, it is usual to carry up a framing, which is bolted to the outer casing, as shown in Figs. 8 and 9, Plate 371, (Artizan, March, 1871), which still further increases the difficulty of charging the basket evenly. Similar, if not greater, inconvenience is felt in the case of overhead machines when emptying the baskets by the proximity of the upright spindle and side frames to the head and shoulders of the men engaged in scooping out the cured sugar. There are also several minor disadvantages inherent to the overhead driven machines, such as the liability of the top bearing to get clogged with sugar, or on the other hand the liability of the oil from that bearing running down into the sugar. In those cases where the basket, instead of being emptied in its place, is removed for that purpose, while another

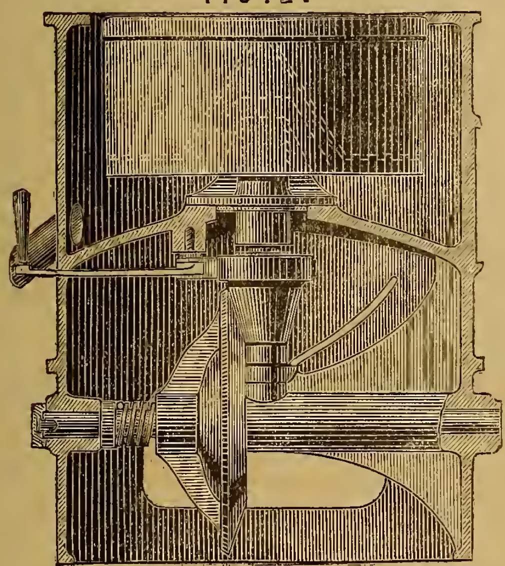
FIG. 1.



that the baskets in some are driven from above, and others from below. The advantage of driving from above consists in obtaining a bearing at each end of the driving spindle, and thereby obviating the necessity of an overhanging bearing, and consequently by this arrangement a lighter spindle may be used than when the basket is driven from below. There are a great number of centrifugals at present in use upon this principle, working most satisfactorily, but we do not consider them as convenient basket already charged is fitted on the machine, the overhead motion is entirely inapplicable. We remember having erected an overhead motion centrifugal in which the driving spindle was made telescopic; the spindle being "shut up" to enable the baskets to be shifted, but as in order to effect this object considerable "play" had to be allowed it was not to be wondered at that the machine exhibited rather too much playfulness when driven at a high speed.

It will be seen from the foregoing remarks that the system of driving centrifugal machines from beneath the basket is far superior to any other method, inasmuch as it leaves the top of the basket entirely open both for inspection and manipulation. In the accompanying engravings, (Figs. 1 and 2), is illustrated Lessware's arrangement, which has recently been patented, and which is manufactured by the well known firm of Messrs. J. and H. Gwynne, of the Hammersmith Iron Works. It will be seen that in this arrangement, the engine is bolted to the cylindrical casing of the centrifugal, which is made sufficiently strong to take the strain and absorb the vibration when working at a high speed. The engine is similar to those made by Messrs. Gwynne for driving their centrifugal pumps, where also a large number of revolutions are required, the stroke

FIG. 2.



of the cylinder being very short in proportion to its diameter. Thus, for driving a centrifugal with a 30in. basket the cylinder is 4½in. in diameter, and 4½in. stroke. All the bearing surfaces are made very large to allow for the wear and tear incidental to a high speed. The piston rod, connecting rod, and crank shaft are made of steel, and all the working parts are accurately balanced. The crank shaft which runs through the casing having a bearing at each side, carries a bevil friction wheel as shown in Fig. 2. This wheel is held up against the friction pinion upon the upright spindle, carrying the basket by means of a spiral spring as shown in the engravings. From the high rate at which the engine is designed to be driven, this friction wheel and pinion is the only multiplier required, and thus the driving parts are reduced to a minimum. A break is fitted to the upright spindle just above the friction pinion for the purpose of stopping the basket previous to its being lifted out. An oil box is fitted on the casing, which has a series of tubes to convey the oil to the bearing of the upright spindle, which are otherwise difficult to reach. As the whole of the machinery is contained in one casting which both forms the bed plate of the engine and the casing of the centrifugal, very little foundation is required; brickwork or concrete 18in. deep being quite sufficient. For the same reason the vibration in these machines when running at full speed is remarkably small, although doubtless the perfect smoothness of its working is partly due to the excellence of the workmanship.

The baskets of this machine are different from any we have hitherto seen, and constitute the chief peculiarity of the invention. It is well known that in ordinary baskets, in which the wire gauze casing is strengthened by vertical or horizontal ribs, the sugar is very liable to stick in moist lumps opposite to those ribs, in consequence of the meshes of the gauze being closed by them. For this reason the ribs are usually made as narrow as possible, but even then the objection to ribs cannot be entirely removed. Mr. Lessware makes the basket altogether without ribs by fitting three casings round the basket, each of which is perforated. Thus, the inner casing is formed of thin copper perforated as closely as possible with very small holes; round this is placed a casing of wire gauze, and outside the whole a casing of sheet copper, in which the holes are somewhat larger and farther apart. By this means a basket of ample strength is obtained without having recourse to any stays. We may mention that these baskets have been thoroughly tried, and have been found to answer very well.

In Figs. 3 and 4 is illustrated a Belgian design for a centrifugal, with the engine on the same bed-plate. This machine was designed, and

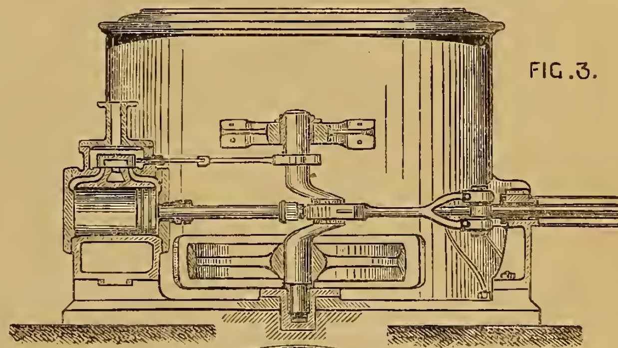


FIG. 3.

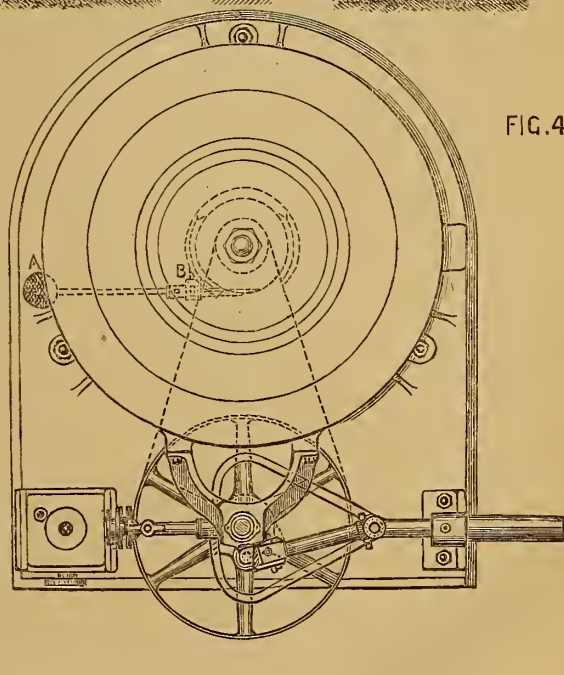


FIG. 4.

recently patented, by Mr. Fouqnemberg, and is a nice compact arrangement, although we consider the strap is somewhat too short. This defect, however, could easily be remedied by slightly increasing the length of the bed-plate. The engravings are so self explanatory that little description is needed. The break on the upright spindle for the purpose of stopping the basket is worked by the foot, the lever A being fitted to one arm of a bell crank at B (Fig. 4), the other arm of which is attached to the strap of the break. The engine is horizontal, the crank shaft working vertically, and is somewhat like a steeple engine

laid on its side. The strap pulley is made very wide, in order to compensate for the shortness of the strap. The arrangement is decidedly simple, and although we cannot see much novelty in it, it can evidently be constructed at a moderate cost.

The speed at which the basket of a centrifugal should be driven, is generally reckoned at about 10,000 circumferential feet per minute. Thus a 48in. centrifugal is usually driven at about 800 revolutions per minute, a 36in. machine having to make about 1,060 revolutions in the same time.

The method usually adopted for curing sugar by means of centrifugals is as follows :—The concentrated syrup having been allowed to stand in the coolers previously described for about 24 hours, or if boiled low for 48 hours, is thoroughly mixed up ; the crust at the top being broken up. It is then charged into the centrifugal, the quantity contained in each charge varying considerably with the quality of the sugar. Thus, if the sugar has a fine open grain, a much larger charge may be employed than when the mass has a very indifferent grain, or as it is usually termed, sticky or pasty. For large grained sugar, we usually prefer a charge of about $2\frac{1}{2}$ to 3 cwt. for a 48in. machine, although some persons put in as much as it will conveniently hold, or about $4\frac{1}{2}$ cwt. We do not, however, consider that anything is gained by filling the basket, as the increased thickness of sugar through which the molasses contained in the inner portion has to be driven, increases the length of time at which the machine has to be kept running in a much greater proportion than that due to the larger quantity of sugar thus obtained. For instance, with good sugar a charge of $2\frac{1}{2}$ cwt. would be thoroughly cured in from three to four minutes, whereas a charge of 4 cwt. would require at least eight to ten minutes. Another objection to a heavy charge is the difficulty of judging when the sugar nearest to the outside of the basket is properly cured, and it not unfrequently happens that the first scoopful of sugar from the inside of the basket, reveals an imperfectly cured mass underneath. When this happens, it is usual to start the machine afresh, but by so doing an enormous strain is thrown upon the driving spindle, as the scoopful that has been removed has destroyed the correct distribution of weight, which is made unpleasantly evident by the excessive vibration of the machine. With low, sticky sugars, a smaller charge is preferable, say from 1 cwt. to 2 cwts. of sugar, while the time occupied in freeing the grain of sugar from the molasses is considerably greater. Sometimes with very inferior sugar, it will take from twenty minutes to half an hour to cleanse a single charge. With a properly constructed sugar house, however, these low sugars ought never to be made, as they cannot yield a profit to the planter. In charging a centrifugal, the basket should be made to revolve slowly, so that the weight is evenly distributed over the bottom ; and as the speed is gradually increased, the semi-fluid mass is caused to run up the perforated sides of the basket, by virtue of the centrifugal force imparted to it. As the speed is still further increased the fluid portion, or molasses, flies through the perforations into the outer casing, and runs off through the spout provided at the bottom. After the centrifugal has run a short time at full speed the contained sugar changes colour, turning from a dark brown to a pale straw colour, while the quantity of molasses running out of the spout in the outer casing gradually decreases. As soon as the molasses ceases running out of the spout, the sugar is considered to be sufficiently cured, when the machine is stopped by means of the break and the sugar is immediately removed by means of wooden scoops. The appearance of the sugar, if properly made, or if made by machinery similar to that described in previous numbers of The Artizan, is precisely similar to fine grocery sugar, which in fact it is. In some cases this sugar is packed direct into hogsheads or boxes for shipment, but in others it is first exposed to the heat of a tropical sun, which has the effect of making it quite crisp, in which state it is supposed to be better able to stand a sea voyage. As we have already observed, it is very difficult to specify the time which any particular description of sugar requires to remain in the centrifugal in order to be properly freed from molasses, we may mention that we have found it to be the best plan to watch the molasses spout in the outer casing. At first—and especially with large grained sugar—the quantity is very large, but it gradually diminishes until the stream is reduced to drops at short intervals. By leaving it about half a minute longer the sugar is in all probability cured. Upon removing this first basketful, it can easily be judged whether the rest of the contents of the cooler requires a little extra time, or whether it will do without the last half minute. Some persons consider that they can judge when the sugar is sufficiently cured by observing its colour in the basket, but as we have already pointed out it often happens that the exposed surface is perfectly cured whilst the sugar underneath is quite wet. When it is desired to make a very light coloured sugar a little hot water, or what is better a little hot clarified sugar is carefully poured into the centrifugal, after the molasses has been driven off the contained sugar. As a crystal of sugar is invariably white, and consequently the colour of raw sugar is only due to a thin film of molasses still remaining in the crystals, this process has the effect of washing them and producing white or very nearly white sugar.

When the syrup is very highly concentrated, it is frequently passed into the centrifugals while hot, as otherwise it would set into a solid mass in the coolers. This system of high concentration is, in our opinion, only suited to refineries at home where vacuum pans are employed, skilled labour abundant, and fuel cheap. We have previously remarked that boiling water dissolves about five times as much sugar as cold water, and consequently, when working with hot syrup, it is not only the uncrystallisable portion that is driven through the sides of the basket, but a large quantity of sugar in solution which would otherwise have crystallised. Very highly concentrated syrup is also open to the objection, that it does not allow the crystals to properly develop, and consequently a fine open grained sugar cannot be obtained.

The molasses expelled by the centrifugals is generally returned to a wetzel pan, and re-concentrated, a very fair sugar being usually obtained from it. Sometimes this process is repeated, but it will generally be found more profitable to make it into rum. In countries where rum commands a high price, as, for instance, in Jamaica it is never worth while to reconcentrate the juice ; in fact, during the Crimean war, it was found more profitable to make all the cane-juice into rum instead of sugar but these details can only be arrived at by practice.

(To be Continued.)

INTERNATIONAL EXHIBITION.

Paget's Patent Cleats.

We noticed in our last issue some ingenious blocks made by Mr. Arthur Paget, of Loughborough, and we now have the pleasure of giving our readers illustrations of a new cleat, or rope-holder, which is also the invention of the same gentleman. Mr. Paget was led to invent these cleats by observing the difficulty sailors have with the ordinary cleat or belaying-pin in making fast quickly a rope which they have "got taut;" and the result of this often was, that when sailors were hauling a rope—say, the sheet of a sail—to get it taut, it would very frequently happen that after three or four of them had, with great exertion, "got in" a length of three feet or so, a gust of wind would strike the sail, and cause it to carry out not only the length already gained, but too often an additional length also, before they could make the rope fast. Under those circumstances the hauling-in has, of course, to be done over again—an operation necessitating much hard work, and frequently, as "Jack" is not extremely particular in his language, much hard swearing also. To save from useless labour a class of men who have plenty of it which is unavoidable, Mr. Paget set to work to scheme something which would enable a man to fasten a rope quickly. There is also another *sine qua non* in a perfect cleat, or rope-holder, namely, that as well as being able to fasten a rope quickly a man must also be able to unfasten it quickly ; and this latter is of even the greater importance, as the speed with which the rope can be set at liberty is often, in sailing, a matter of life or death to a boat's crew. There is an old proverb on this subject familiar to those who have been at sea, and illustrating what important results may be the consequence of a minute's loss of time in undoing even an easy knot in a rope. The proverb is, "Two half hitches lost

the king's ship," and although we should not like to vouch for its literal truth, this proverb undoubtedly has good foundation. It would be difficult to estimate how many serious accidents, such as upsetting of boats, &c., resulting in but too many instances in loss of life, have been occasioned simply from its being impossible to let go a sheet or other rope as quickly as in many instances desirable. We think a perusal of the following will show our readers that Mr. Paget has succeeded in producing a cleat which gives very great facilities for both quickly making fast and instantaneously releasing ropes and cords of all sorts.

The construction of Mr. Paget's cleat is shown by the perspective view of one form, Fig. 1, and the diagram, Fig. 2. From the latter it

Fig. 1.

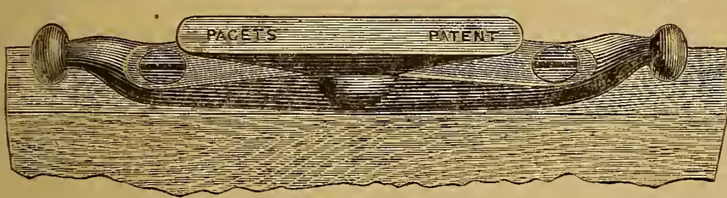
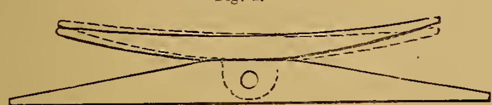
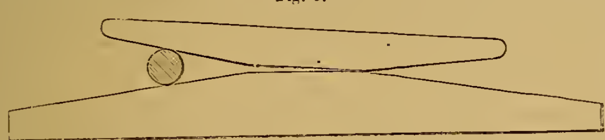


Fig. 2.



will be seen that the front part, or cleat proper, is so attached to the base at its centre that it is capable of a small extent of motion, as shown by the dotted lines. When a rope is to be made fast it is first placed under one horn of the cleat, which will then assume the position shown in Fig. 3, and the rope is then passed once round the cleat, and so under

Fig. 3.



Cleat shown with rope laid under first end of Cleat.

the second horn, and then pulled moderately tight, as shown in Fig. 4. It will then be seen that the rope is held by a combined action of wedging

Fig. 4.

Cleat shown with rope laid under both ends of Cleat and so held fast.

and leverage, and is held so tight that no pulling from the end first laid will loose it—indeed, the rope can be broken without loosing it; but there is no risk of "jamming," however tightly the rope may have been pulled, as the *last* laid end can always be easily taken out by the hand, and the rope is then at liberty instantaneously. On board ship, where ropes sometimes "lead" at right angles to the cleats, they are made with one or two fixed horns or fair-leaders at the ends, and under one of these a rope leading *at right angles* to the cleat is usually laid; but for home use, that is, for cords of blinds and such purposes, this is not necessary. We all know the trouble experienced with the cords of a Venetian and other blinds. The cord has ordinarily to be tied to two curved hooks or pins: persons not accustomed to do this find great difficulty in making the requisite knots, and a greater difficulty still in untying them, especially if, as not unfrequently happens, one person has to untie the knots which another has tied; whereas with these cleats it is evident that no trouble can occur in either fastening or unfastening a cord. These cleats are made to hold the smallest possible strings as well as the largest cables, and will, we have no doubt, when more generally known, be universally used where ropes or cords are to be held.

H.M.S. "DEVASTATION."

The launch of this great turret frigate was accomplished at Portsmouth dockyard on the 12th ult. The *Devastation* is the first of her class afloat as a seagoing monitor carrying 35-ton guns and coated with thicknesses of 14in., 12in. and 10in. armour, and is, therefore, looked upon to a very great extent as a triumph of the turret over the broadside principle of carrying guns of exceptionally large calibre at sea.

After the water had been admitted by the lifting of the caisson and the vessel swam by her own weight upon the water, she was found to float at exactly the water calculated, and which had been previously marked upon her sides, thus proving unmistakably that the total weights of material which had been worked into the ship had been correctly recorded during the progress of construction. The weight of the ship at her light draught was 3,422 tons, and her weight, when completed and with all on board ready to go to sea, will be about 9,050 tons. The vessel was christened by Mrs. Goschen, and was afterwards hauled out of dock into the steam basin by means of hausers made fast to her stern. The *Devastation*, with her sister vessel the *Thunderer*, building at Pembroke, was designed by Mr. E. J. Reed, C.B., the late Chief Constructor of the Navy, as a type of seagoing monitor, improved upon the American system, to carry exceptionally heavy armour and armament, with a large coal-carrying capacity, without masts and sails, able to steam over long distances and keep the sea for a considerable time, but not intended for the continuous sea services which cruising ships in the Navy have to perform. The following is a general description of this great sea-going monitor:—Length between perpendiculars, 285ft., with an extreme breadth of hull, at amidships and for tonnage, of 58ft. The armour of the hull, with its timber backing and iron framing, projects out from the hull in a band encircling the hull in its upper part from the level of the covering deck to a certain distance below the waterline, and this armoured band, therefore, increases the extreme breadth of the ship at the water-line from the 58ft. given for tonnage measurement to an actual measurement amidships of 62ft. 3in. At each end of the ship, owing to the tapering off there of the armour plating and backing, the addition to the actual measurement of the hull is in somewhat less proportion. The measurement of the hull is 4,406 tons, O.M., and the intended mean draught of water at sea, when filled up with coals and stores of all kinds is 26ft. At this draught the turret ports will be 13ft. 6in. above the ship's line of flotation. The outer skin of the hull has been built of iron plating, which has been subjected to most severe tests, and is, therefore, of proved excellence of quality in proportion to its weight. The distance between the outer and inner skins of the double bottom is 4ft. 6in. in the central part, and this distance, taking into account the depth of the timber bedding upon which the boilers rest, gives the position of the lowest weight carried by the ship as 6ft. 6in. above the outer skin, or hull proper, of the ship. The armoured belt, projecting round the upper part of the ship's hull, is 9ft. 3in. wide amidships, and is built out from the ship's side:—1. Two thicknesses of ¾in. iron plates; 2. 18in. of teak planking worked on horizontally in ¾in. iron frames; 3, two rows of armour plates bolted on horizontally, the upper row covering the ship's water line, and protecting all the vital parts of the ship, being 12in. in thickness and 5ft wide, and the lower row, extending downward below the water line, being 10in. in thickness and 4ft. 3in. wide. This band of armour plating gradually decreases in thickness and breadth as it approaches the extreme ends of the ship, the thickness of the armour at the stem and stern being 8in. and the breadth of the band 5ft. 6in. The hull is finally covered in with 3in. of iron plating rivetted down upon the rolled iron beams, with two thicknesses of teak planking over all. So far, therefore, the form of the hull of the *Devastation* resembles, roughly speaking, the capital letter U, each of the upper sides of the figure giving the position of the armour plate band. Drawing a line across the top of the U represents the covering-in deck of 3in. iron, and the two thicknesses of timber planking. Upon this deck proper of the ship's hull is built the breastwork, and its superimposed deck, with all the necessary openings to the interior of the ship. This is 156ft. in length, 50ft. in width amidships, and has conical ends forward and aft, with 7ft. height all round. Abreast of the two turrets, which, with the funnel, conning tower, and all the openings below, as already stated, stand inside it, the armour plating is 12in. in thickness, with the same thickness at the fore and after conical ends. Amidships and between the two turrets the thickness of the armour plating is 10in. The backing of the timber planking, &c., is similar to the backing to the armour belt of the hull. The deck of the breastwork is composed of two inches of iron plating, covered with two layers of timber planking. The two turrets, which rise above this elliptical breastwork as the elevated circular revolving batteries of a floating and steaming iron fortress, differ materially in their mounting from those in the American sea-going monitors, and also

from all those mounted on board the turret vessels of the British Navy, if we except the *Cerberus*, *Abyssinia*, and *Magdala*, built for the Colonial Governments. We have said that the *Devastation* is an improvement upon the American plan for sea-going monitors. The *Devastation's* turret gunports, with the ship at sea, will be 13ft. 6in., out of water, measuring from the lower sills. The two turrets each measure 24ft. 3in. in their internal diameter, and are being built up in five laminæ, as follows:—Inner skin, of two five-eighth inch plates, laid over each other; then six inches of teak, horizontally laid in iron frames, and on this teak six-inch armour plates. Over the six-inch plating comes nine inches of teak planking, set in iron frames, laid vertically, and lastly over all, as the outside skin, armour plates of eight inches in thickness. On the rear face of the turret, the outer eight-inch armour-plating which protect the front are superseded by plating six inches in thickness, this being considered in proportionate strength in action to the front plating. Each turret will be armed with two Frazer muzzle-loading rifled guns of 35 tons each—the most powerful rifled ordnance, whether for land or sea service, as yet in existence. The engines for the ship have been manufactured by Messrs. John Penn and Son, of Greenwich. They consist of two pairs of engines, driving twin screws independently, of a collective nominal power of 800-horse, but constructed to indicate, with the exertion of full-boiler power, seven times that force. The coal-carrying capacity of the ship is no less than 1,800 tons. With two independently working engines and screws the *Devastation* can well dispense, as a steam-fighting machine not intended for lengthened cruises, with the expensive paraphernalia of masts, yards, and sails, however painful it may be to some naval men to see such things discarded in the outfit of one of Her Majesty's ships. The turrets have special steam-power applied for turning them, and they can also be turned by hand as on board the *Royal Sovereign*. They will also have the necessary holding power to keep them steady in a seaway. The stem or prow of the hull projects in a ➢ form to just sufficient an extent to give the ship the power of using it as a ram without the danger, from an excessive length, of its becoming entangled in the wreck of the stove-in side of an enemy. Bilge, or rolling, keels, to steady the ship at sea, are ordered to be fitted of such dimensions as can be applied in dock. The great width of the *Devastation* amidships at her bilges will, however, limit the depth of these keels. The ship's mean draught of water can be maintained at sea when coals and stores are getting light. A steam steering engine and wheels will be fitted as the ship's principal steering power, but the ordinary method, as a matter of precaution will also be available.

NEW CITY TERMINUS.

On the 1st ult., the extension of the Metropolitan District Railway from Blackfriars into the centre of the City was completed, and, together with the enlarged station at South Kensington, and the North Junction line between Kensington High-street station and the Addison-road station of the West London Railway, was formally opened by the Earl of Devon, the chairman of the District Company, in the presence of the Premier, the Duke of Sutherland, the Lord Mayor, and other representatives of the Corporation of the City of London, several of the metropolitan members of Parliament, and many gentlemen distinguished by the part they have taken in railway enterprises of great magnitude. The two portions of the line opened on this occasion carry the Metropolitan District system to within three-quarters of a mile of Tower-hill, where, according to the original scheme, the circuit was to be completed by a junction with the Metropolitan. The new station has a frontage in Cannon-street opposite to the juncture of that thoroughfare with Queen Victoria-street, and is at the thin end of a wedgeshaped block of buildings standing between Bow-lane and New Earl-street. It may be seen from the corner of the Mansion-house, and is within two minutes' walk of the Bank of England. So much of the building as is above ground will be divided into booking-offices, waiting-rooms, company's offices, dining saloons, &c., while a straight, well-lighted staircase leads by a gradual descent to the station platform, which is 23ft. below the level of the street. It was not until the end of March that the contractors were able to begin the heaviest portion of the work on the new section of the line. Since then, however, 2,000 workmen have been employed day and night in the construction of the terminus and the approach to it for a distance of 280 yards. The construction of this section of the line presented difficulties of an extraordinary character, even to those who had become adepts in the art of tunnelling through a network of sewers and gas and water-mains without disturbance to the tenants of the houses above. Mr. John Fowler, the engineer under whose direction the works have been carried out, found that the Metropolitan Board of Works had constructed vaults 12ft. deep, with two adjacent subways, beneath Queen Victoria-street, and in order to carry the line under these passages two tiers of wrought iron girders were used—the lower tier supporting the subways and the tier above them bearing the road. The railway has been so designed as in no way to interfere with the erection of buildings along either side of Queen Victoria-street. The line diverges from this thoroughfare near Bread-street-hill and passes on the south side of Trinity-lane. At the eastern end of the station abutting on Garlick-hill, a perfect passage, about 20ft. wide, with a pointed arched roof, built of square chalk, and with roughly moulded ribs, was discovered. Houses were built over the arch, which is believed to be a work of the 14th century, and to be a portion of a passage which ran from somewhere north of Cannon-street down to the river side. Mr. Fowler was aided in successfully carrying out his design by Mr. B. Baker, A.S.C.E., chief assistant; and Mr. Cooper, resident engineer. The contract for the works has been executed by Messrs. Kelk, Waring Brothers, and Lucas, under the direction of their agent, Mr. T. Walker.

STEAM BOILER EXPLOSIONS.

The select committee appointed to inquire into the cause of steam boiler explosions, and who were subsequently empowered to inquire as to the best means of preventing them, have considered the matters to them referred, and have recommended that it be distinctly laid down by statute that the steam user is responsible for the efficiency of his boilers and machinery and for employing competent men to work them; that, in the event of explosion, the *onus* of proof of efficiency should rest on the steam user; that in order to raise *primâ facie* proof it shall be sufficient to show that the boiler was at the time of the explosion under the management of the owner or user or his servant, and such *primâ facie* proof shall only be rebutted by proof that the accident arose from some cause beyond the control of such owner or user; and that it shall be no defence in an action by a servant against such owner or user being his master that the damage arose from the negligence of a fellow servant: that whenever an explosion happens to a boiler, whether such explosion is or is not attended with loss of life or injury to person or damage to property, it shall be the duty of the user to report the same to the coroner of the district; and the coroner to whom the accident is reported, or, in failure of such report, on the fact coming to his knowledge, shall hold an inquiry, and apply to the Board of Trade, and the Board of Trade shall thereupon direct one of their competent practical surveyors of boilers, or some other practical person, to assist the coroner in the investigation; that the coroner shall report the result of each investigation to the secretary of State for the home department, and that such reports be annually presented to Parliament.

GLASS ENGRAVED BY SAND.

A curious discovery has lately been made public through the *Journal of the Franklin Institute*, (U.S.) by Mr. B. F. Tilghman, of Philadelphia. Almost every one has noticed that glass exposed to the wind-driven sand near the sea-shore soon loses its polish, and in a measure its transparency. This is one of many examples of the erosion of surface, when exposed to a stream of moving particles, and it seems strange that, although engineers have had continually to make provision against this cutting effect, it should not have ere this been turned to some good account. Acting on this principle, the discoverer forces a jet of quartz sand against the substance to be cut. For grinding glass he uses a common rotary fan 30in. in diameter, making about 1,500 revolutions per minute, which gives a blast of air of the pressure of about 4in. of water, through a vertical tube, 2ft. high by 60in. long and 1in. wide. Into the top of this tube the sand is fed, and falling into the air-current and acquiring velocity from it, is dashed down against the sheets of glass, which are slowly moved across, about 1in. below the end of the tube. About 10 or 15 seconds' exposure to the sand blast is sufficient to completely grind or depolish the surface of ordinary glass; so that sheets of it carried on endless belts may be passed under this 1in. wide sand-shower at the rate of 5in. forward movement per minute. In the machine in use for this purpose, the spent sand is reconveyed to the upper hopper by elevators, and the dust made by the sand-blast (which might otherwise be a source of annoyance to the workmen) is drawn back into the fan, and thence passes with the wind into the blast-ton, and again mingles with the shower of sand upon the glass. By covering parts of the glass surface by a stencil or pattern of any tough or elastic material, such as paper, lace, caoutchouc, or oil-paint, designs of any kind may be engraved. There is a kind of coloured glass made by having a thin stratum of coloured glass melted or "flashed" on one side of an ordinary sheet of clear glass. If a stencil of sufficient toughness is placed on the coloured side, and exposed to the sand-blast, the pattern can be cut through the coloured stratum in from about four to twenty minutes, according to its thickness. The theoretical velocity of a current of air of the pressure of 4in. of water, he calculates, is (neglect-

ing friction) about 135ft. per second; the actual velocity of the sand is doubtless much less. If a current of air of less velocity is used, say about one inch of water, very delicate materials, such as the green leaves of the fern, will resist a stream of fine sand long enough to allow their out-lines to be engraved on glass. By graduating the time of exposure with sufficient nicety, so as to allow the thin parts of the leaves to be partly cut through by the sand, while the thicker central ribs and and their branches still resist, the effect of a shaded engraving may be produced. The grinding of such a hard substance as glass by an agent which is resisted by such a fragile material as a green leaf seems at first rather singular. The probable explanation is, that each grain of sand which strikes with its sharp angle on the glass pulverises an infinitesimal portion, which is blown away as dust, while the grains which strike the leaf rebound from its soft elastic surface. The film of bichromatised gelatine, used as a photographic negative, may be sufficiently thick to allow a picture to be engraved on glass by line sand, driven by a gentle blast of air. For cutting stone, the inventor uses steam as the impelling jet; the higher the pressure, the greater is the velocity imparted to the sand, and the more rapid its cutting effect. In using steam of about 100 pounds pressure, the sand is introduced by a central iron tube, of about 3-16in. bore, while the steam is made to issue from an annular passage surrounding the sand-tube. A certain amount of suction of air is thus produced, which draws the sand through the sand-tube into the steam jet, and both are then driven together through a tube about 6in. long, in which the steam imparts its velocity to the sand, and finally strike on the stone, which is held about an inch distant from the end of tube. At the spot struck a red light is visible, as if the stone were red hot, though really it is below 212° Fahr. The light is probably caused by the breaking up of the crystals of the sand and stone. The cutting effect is greatest when free escape is allowed for the spent sand and steam. In making a hole of a diameter but slightly greater than that of the steam jet, the rebounding steam and sand greatly interfere with and lessen the efficiency of the jet.

Under favourable conditions, using steam which he estimated as equal to about $1\frac{1}{2}$ H.P., at a pressure of about 125 pounds, the cutting effect per minute was about $1\frac{1}{2}$ cubic inches of granite, or 3 cubic inches of marble, or 10 cubic inches of soft brown sandstone. By means of flexible or jointed connecting tubes, the blast-pipe is made moveable in any direction; grooves and moulding of almost any shape can thus be made, or, by means of stencil-plates, letters or ornaments can be cut either in relief or intaglio, with great rapidity in the hardest stone. At a high velocity, quartz sand will cut substances much harder than itself, as before stated. With a steam jet of 300 pounds pressure, a hole $1\frac{1}{2}$in. in diameter was cut through a piece of corundum, $1\frac{1}{2}$in. thick, in 25 minutes.

A hole 1in. long and $\frac{1}{4}$in. wide was cut through a hard steel file $\frac{1}{4}$in. thick in 10 minutes with a jet of 100 pounds steam. A stream of small lead shot, driven by 50 pounds steam, wore a small hole in a piece of hard quartz; the shot were found to be only very slightly flattened by the blow, showing their velocity to have been moderate. Among the curious examples of glass cut by this sand-blast was shown a piece of ordinary window glass, which, having been partially protected by a covering of wire gauze, had been cut entirely through, thus producing a glass sieve, with openings of about 1-12th of an inch, the intervening glass meshes being only 1-16th of an inch wide. This seems to have been produced more as a curiosity than for any practical purpose. Should such a sheet of perforated glass be required, it is questionable if it could be produced from a solid sheet by any other method. A microscopic examination of the sheet glass depolished by this process shows a succession of pits formed by the blows of the impinging grains of sand, and looks more uniform than do surfaces ground by any rubbing process. This steam-sand jet has already been introduced to clean cast-iron hollow ware previous to tinning the interior. Heretofore the interior surface has been turned, it having been found necessary to remove a thin shaving in a lathe to obtain a clean surface. The surface is cleaned more rapidly by the sand-blast, and even more perfectly, because it penetrates into any holes or depressions which the turning tool could not reach. It is also probable that the sand striking the particles of plumbago, which separate the particles of metallic iron in ordinary gray cast-iron, will remove them, and thus expose a continuous metallic surface to take the tin.

It has been noted by those familiar with the cutting or dressing of stone, that some materials—such as granite—are very much injured, or "stunned," by the blows of the cutting tool, and after being hand-dressed a thickness of perhaps from $\frac{1}{8}$th inch to $\frac{1}{4}$th inch has to be ground away to produce a uniform surface. By this sand-cutting process, the surface is not injured, is not "stunned," and is ready for polishing at once. One curious fact connected with its use is, that when a surface to be cut in intaglio or otherwise is partially protected by templates of metal, these templates curl up under the blows of the sand, so that paper patterns are really more durable than patterns cut from brass. Sheet steel, cut into shape and then hardened, will also curl up under the blows of the fine particles of sand, unless protected by sheets of yielding material. Fine lace will protect glass during the depolishing process, and leave its designs in polished lines on a ground surface.

LAUNCH OF H.M.S. "CYCLOPS."

On the 18th ult., the ironclad double turret-ship *Cyclops* was launched by the Thames Shipbuilding Company from their dockyard at Blackwall. The launch was in every way successful. Miss Rolt, daughter of Mr. Peter Rolt, chairman of the company, christened the vessel. The *Cyclops*, although very similar in construction to the *Magdala*, built by the Thames Company under contract with the India Government for the protection of Bombay harbour, and delivered by them to the authorities there in February last, is the first of a class of ships to be known as the *Cyclops* class, and intended for home harbour service. Four of these vessels were ordered by the Admiralty in September last, of different firms, soon after the outbreak of the Franco-Prussian War, and a general European conflict seemed imminent. As under the circumstances the early completion of these vessels was considered a matter of great importance, the Thames Shipbuilding Company made every arrangement to push forward the work as rapidly as possible, and with such success that the *Cyclops* has been launched in the unprecedentedly short period of nine months from the date of the first keel plate being placed upon the blocks, and considerably within the contract time. The rapidity with which the works have been carried out will be better understood when we state that 1,200 tons of ironwork have been put into the ship, the whole of the teak backing fitted to the hull, breastwork, turrets, &c., and upwards of 700 tons of armour already been fitted and bolted to the vessel. The *Cyclops* is a double turret-ship, with a hull 225ft. long and 45ft. beam, with a belt of armour 7ft. wide in two strakes, the upper one 8in. thick and the lower one 6in. thick amidships, tapering fore and aft. Above the hull is raised a breastwork 117ft. by 34ft., plated with 6ft. 6in. of armour, varying in thickness from 8in. or 9in. This breastwork protects the engines and machinery for working the turrets, which are built at either end of it, and are plated with 9in. armour, thickened to 10in. in the way of the ports; there is also a pilot tower 17ft. in height, plated with 8in. and 9in. armour for the protection of the officer who may be directing the movements of the ship. The vessel is built with a water-tight double bottom amidships, in addition to her numerous watertight compartments. Her engines are of 250-h.p. nominal, by Messrs. Elder and Co., of Glasgow, and are calculated to give the vessel a speed of 10 knots. Her principal dimensions are—length between perpendiculars, 225ft.; breadth extreme, 45ft.; and depth in hold, 16ft. 2in.; burden in tons, 2,107 old measurement. Her armament will consist of two 18-ton guns in each turret, her gun fittings being of the most recent and improved construction. She will be ready for service in three months from the present time. Soon after she was launched she was taken in tow by three powerful steamtugs and placed in the Victoria Docks.

ROYAL INSTITUTION OF GREAT BRITAIN.

ON THE GASEOUS AND LIQUID STATES OF MATTER.

By Thomas Andrews, M.D., F.R.S., Vice-President of Queen's College, Belfast.

The liquid state of matter forms a link between the solid and gaseous states. This link is, however, often suppressed, and the solid passes directly into the gaseous or vaporous form. In the intense cold of an Artic winter hard ice will gradually change into transparent vapour without previously assuming the form of water. Carbonic acid snow passes rapidly into gas when exposed to the air, and can with difficulty be liquefied in open tubes. Its boiling point, as Faraday has shown, presents the apparent anomaly of being lower in the thermometric scale than its melting point; a statement less paradoxical than it may at first appear, if we remember that water can exist as vapour at temperatures far lower than those at which it can exist as liquid. Whether the transition be directly from solid to gaseous, or from solid to liquid, and from liquid to gaseous, a marked change of physical properties occurs at each step or break, and heat is absorbed, as was proved long ago by Black, without producing elevation of temperature. Many solids and liquids will for this reason maintain a low temperature, when surrounded by a white hot atmosphere, and the remarkable experiment of solidifying water, and even mercury, on a red-hot plate, finds thus an easy explanation. The term spheroidal state, when applied to water floating on a cushion of vapour over a red-hot plate, is, however, apt to mislead. The

water is not here in any peculiar state. It is simply water evaporating rapidly at a few degrees below its boiling point, and all its properties, even those of capillarity, are the properties of ordinary water at 96·5° C. The interesting phenomena exhibited under these conditions are due to other causes, and not to any new or peculiar state of the liquid itself. The fine researches of Dalton upon vapours, and the memorable discovery by Faraday of the liquefaction of gases by pressure alone, finished the work which Black had begun. Our knowledge of the conditions under which matter passes abruptly from the gaseous to the liquid, and from the liquid to the solid state, may now be regarded as almost complete. In 1822, Cagniard de La Tour made some remarkable experiments, which still bear his name, and may be regarded as the starting point of the investigations which form the chief subject of this address. Cagniard de La Tour's first experiments were made in a small Papin's digester, constructed from the thick end of a gun barrel, into which he introduced a little alcohol and also a small quartz ball, and firmly closed the whole. On heating the gun barrel with its contents over an open fire, and observing from time to time the sound produced by the ball when the apparatus was shaken, he inferred that after a certain temperature was attained the liquid had disappeared. He afterwards succeeded in repeating the experiment in glass tubes, and obtained the following results:—An hermetically-sealed glass tube, containing sufficient alcohol to occupy two-fifths of its capacity, was gradually heated, when the liquid was seen to dilate, and its mobility at the same time to become gradually greater. After attaining to nearly twice its original volume, the liquid completely disappeared, and was converted into a vapour so transparent that the tube appeared to be quite empty. On allowing the tube to cool, a very thick cloud was formed, after which the liquid reappeared in its former state. It is singular that in this otherwise accurate description, Cagniard de La Tour should have overlooked the most remarkable appearance of all, the moving or flickering striæ, which fill the tube when, after heating it considerably, the temperature is quickly lowered. This phenomenon was first described by myself in 1863, as it is seen in carbonic acid, which has been partially liquefied by pressure, and afterwards heated a little above 31°. It may be observed on a larger scale and to great advantage by heating such liquids as sulphurous acid or ether in hermetically-sealed tubes. The experiments whose results I am about to describe have occupied me for a period of fully ten years; they involved the construction of novel forms of apparatus, in which the properties of matter might be studied under varied conditions of temperature and pressure, such as had never been realised before. In my earlier attempts I endeavoured, as others had already done, to use the expansive force of the mixed gases which are disengaged in the electrolysis of water; and I was able in this way to obtain pressures of 150 atmospheres and even more in glass tubes; but the method was in many respects defective, and more than one dangerous explosion occurred, so that I eventually abandoned it. In the apparatus finally adopted, the gas to be compressed is enclosed in a long glass tube, of which the greater part of the length, or about 450 millimetres, has a capillary bore, and the remainder, about 150 millimetres, an internal diameter of two millimetres. The free capillary end is sealed, while the gas in a pure and dry state is passing through; while at the other end the gas is confined by a movable column of mercury. The details of the method by which this is accomplished will be found in the Bakerian lecture for 1869, to which I must also refer for an account of the process by which the original volume of the gas at the freezing point of water, and under one atmosphere of pressure was determined, and also the volumes of the same gas deduced from the observed measurements when it was compressed at different pressures in the capillary tube. A conical protuberance on the capillary part of the tube, a little above its junction with the wider part, corresponded as nearly as possible with a hollow cone in a stout brass flange, the joint being rendered perfectly tight by careful packing. The body of the apparatus consisted of two cold-drawn copper tubes of great strength, to the ends of which four massive brass flanges were firmly attached. Two corresponding flanges or end pieces, each carrying a fine steel screw packed with great care, were bolted on the lower flanges. The success of the experiments depended greatly on the packing of this screw. It was effected by means of a number of leather washers, tightly pressed down and saturated *in vacuo* with melted lard. The apparatus was now filled with water; the flanges with the glass tubes, one containing the gas to be examined, the other air or hydrogen to act as a manometer or measure of the pressure, were bolted down upon the upper flanges of the copper tubes. The joints had always leather washers interposed; and when sufficiently tightened, they resisted any pressure which could be applied, even for an indefinite time. The two copper tubes were connected by a fine horizontal tube, so that the whole of the interior of the apparatus was in free communication. The pressure was obtained by screwing one or other of the steel screws into the water. I have recently had the apparatus constructed of iron and filled with mercury. As mercury is much less compressible than water, the same length of screw produces a greater pressure on the interior of the apparatus, even with a larger cavity. There are other advantages in this form of the apparatus which I hope will facilitate future research. The objection to it is its extreme sensitiveness to changes of temperature, so that a variation of $\frac{1}{100}$th of a degree alters the internal pressure by several atmospheres. In the actual experiments the gas under examination does not come into view till it has entered the capillary tube, and is exposed to a pressure of thirty or forty atmospheres. The limit of the pressure which can be obtained has hitherto been the capacity of resistance of the glass tubes to bursting. Fine thermometer glass tubes of white glass will frequently burst when exposed to a pressure of little more than 100 atmospheres; but green glass tubes of good quality are much stronger, and will easily bear a pressure of 300 atmospheres. One of the strongest forms of glass capillary tube for resisting internal pressure is obtained by drawing out a thick green glass tube, heated to softening, till it becomes so fine as to be flexible. Tubes of this kind can easily be drawn out at the blowpipe table, and obtained of very uniform bore. I have compressed air in such tubes to $\frac{1}{100}$th of its ordinary volume without bursting the tubes. Two rectangular brass cases, closed before and behind with plate glass, surround, one the manometer, and the other the tube containing the gas to be examined, and allow them to be maintained at any required temperature by the flow of a stream of water. The manometer was maintained as nearly as possible at the temperature of the apartment; the tube containing the gas, on the contrary, was maintained at different temperatures, according to the object in view. The following observations, published in 1863, contain the results of my earliest experiments on this subject:—"On partially liquefying carbonic acid by pressure alone, and gradually raising the temperature at the same time to 88° F., the surface of demarcation between the liquid and gas becomes fainter, loses its curvature, and at last disappears. The space is then occupied by a homogeneous fluid, which exhibits when the pressure is suddenly diminished or the temperature slightly lowered, a peculiar appearance of moving or flickering striæ throughout its entire mass. At temperatures above 88° no apparent liquefaction, or separation into two distinct forms of matter could be effected, even when a pressure of 300 or 400 atmospheres was applied. Nitrous oxide gave analogous results." The flickering striæ referred to can be admirably shown, as I mentioned before, in hermetically-sealed tubes of strong glass, partially filled with such liquids as sulphurous acid or ether. The liquid must in the first instance be heated a few degrees above what I have designated the "critical" point. The appearances exhibited by the ascending and descending sheets of matter of unequal density are most remarkable, but must be seen in order to be understood. They only occur in this striking form in fluids heated a little above the critical point, and are produced by the great changes of density which slight variations of pressure or temperature produce in this case. They are always a clear proof that the matter in the tube is homogeneous, and that we have not liquid and gas in presence of one another. These striæ are, in short, only an extraordinary development of the movements seen in ordinary liquids and gases when they are heated from below. The experiments to be immediately described will explain their great intensity above the critical point. When the temperature falls below the critical point, the formation of a cloud indicates that we have now heterogeneous matter in the tube, fine drops of liquid in presence of gas. We must take care, however, not to suppose that a cloud necessarily precedes the formation of true liquid. If the pressure be sufficiently great no cloud of any kind will form.

I now proceed to describe the general results of the experiments upon carbonic acid. If a certain volume of carbonic acid at the temperature of 13·1° and under a pressure of one atmosphere be exposed to a gradually increasing pressure, its volume will steadily diminish, but at a faster rate than according to Boyle's law, till at the pressure of 48·9 atmospheres its volume is reduced to about $\frac{1}{81}$ of the original volume at one atmosphere. Liquefaction now begins and continues with very slight augmentation of pressure, the necessity for which I traced to the presence of a minute quantity of air (about $\frac{1}{500}$th part) in the carbonic acid. On augmenting the pressure after liquefaction, the volume slowly diminished, but at a much faster rate than in the case of ordinary liquids. Later experiments carried to much higher pressures have fully confirmed this result. At 21·5° similar results were obtained, but a pressure of nearly 60 atmospheres was required before liquefaction began. At 30·9° C., or 87·7° F., the critical point of temperature is reached. It is the temperature at which liquid ceases to be formed under any pressure. At a temperature a little below this point the surface of separation between liquid and gas becomes very faint and loses its curvature, the density and other physical properties of the liquid and gas being now identical and the tube filled with homogeneous matter. If the temperature and pressure be kept steady, no evidence of heterogeneity will be obtained by optical tests under the most varied conditions

of volume. If we now follow the course of a given volume of carbonic acid gas at 31·1°, or 0·2° above the critical point, we shall find that its course resembles that of the gas at lower temperatures till the volume is reached at which liquefaction might be expected to begin. A rapid but not (as in the case of the formation of the liquid) abrupt fall then supervenes, after which the carbonic acid undergoes a slow diminution of volume as the pressure augments. The curves, which are here exhibited as they were represented in the Bakerian lecture, illustrate very clearly those statements. We have thus carbonic acid at 0·2° above the critical point, and at a pressure of 73 atmospheres behaving very nearly as if it liquefied. At this pressure an augmentation of only $\frac{1}{37}$th of the entire pressure diminishes the volume of the carbonic acid to about one half. Yet during the whole of this fall, no evidence of heterogeneity, or of two states of matter present together in the tube, could at any period be obtained. Carbonic acid at this temperature of 31·1°, and under a pressure of 75 atmospheres, behaves much more as a liquid than as a gas when the pressure is either augmented or diminished; yet it never exhibits under any conditions the characteristic properties of the liquid state; that is to say, no surface of separation is formed by change of pressure, nor will it collect into drops and form a cloud. At 32·5° the fall, when liquefaction might be expected, is less abrupt than at 31·1°; and at 35·5°, although still manifest, it is further reduced. At 48·1° the fall shown at lower temperatures can no longer be distinctly observed, and the curve representing the change of volume approximates to that of a perfect gas. There can be little, if any, doubt that at a higher temperature carbonic acid would behave under augmenting pressures nearly as nitrogen or hydrogen.

I have frequently exposed carbonic acid, without making precise measurements, to much higher pressures than any of the foregoing, and have made it pass without break or interruption from what is regarded by every one as the gaseous state, to what is, in like manner, universally regarded as the liquid state. Take, for example, a given volume of carbonic acid gas at 50° C., or at a higher temperature, and expose it to increasing pressure till 150 atmospheres have been reached. In this process its volume will steadily diminish as the pressure augments, and no sudden diminution of volume, without the application of external pressure, will occur at any stage of it. When the full pressure has been applied, let the temperature be allowed to fall till the carbonic acid has reached the ordinary temperature of the atmosphere. During the whole of this operation no breach of continuity has occurred. It begins with a gas, and by a series of gradual changes, presenting nowhere any abrupt alteration of volume or sudden evolution of heat, it ends with a liquid. The closest observation fails to discover anywhere indications of a change of condition in the carbonic acid, or evidence, at any period of the process, of part of it being in one physical state and part in another. That the gas has actually changed into a liquid would, indeed, never have been suspected, had it not shown itself to be so changed by entering into ebullition on the removal of the pressure. For convenience, this process has been divided into two stages, the compression of the carbonic acid and its subsequent cooling; but these operations might have been performed simultaneously, if care were taken so to arrange the application of the pressure and the rate of cooling that the pressure should not be less than 76 atmospheres when the carbonic acid had cooled to 31°.

We are now prepared for the consideration of the following important question. What is the condition of carbonic acid when it passes, at temperatures above 31°, from the gaseous state down to the volume of the liquid, without giving evidence at any part of the process of liquefaction having occurred? Does it continue in the gaseous state, or does it liquefy, or have we to deal with a new condition of matter? If the experiment were made at 100°, or at a higher temperature, when all indications of a fall had disappeared, the probable answer which would be given to this question is that the gas preserves its gaseous condition during the compression; and few would hesitate to declare this statement to be true, if the pressure were applied to such gases as hydrogen or nitrogen. On the other hand, when the experiment is made with carbonic acid at temperatures a little above 31°, the great fall which occurs at one period of the process would lead to the conjecture that liquefaction had actually taken place, although optical tests carefully applied failed at any time to discover the presence of a liquid in contact with gas. But against this view it may be urged with great force, that the fact of additional pressure being always required for a further diminution of volume is opposed to the known laws which hold in the change of bodies from the gaseous to the liquid state. Besides, the higher the temperature at which the gas is compressed, the less the fall becomes, and at last it disappears.

The answer to the foregoing question, according to what appears to me to be the true interpretation of the experiments already described, is to be found in the close and intimate relations which subsist between the gaseous and liquid states of matter. The ordinary gaseous and ordinary liquid states are, in short, only widely separated forms of the same condition of matter, and may be made to pass into one another by a series of gradations so gentle that the passage shall nowhere present any interruption or breach of continuity. From carbonic acid as a perfect gas to carbonic acid as a perfect liquid, the transition we have seen may be accomplished by a continuous process, and the gas and liquid are only distant stages of a long series of continuous physical changes. Under certain conditions of temperature and pressure, carbonic acid finds itself, it is true, in what may be described as a state of instability, and suddenly passes, with evolution of heat and without application of additional pressure or change of temperature, to the volume, which by the continuous process can only be reached through a long and circuitous route. In the abrupt change which here occurs, a marked difference is exhibited, while the process is going on, in the optical and other physical properties of the carbonic acid which has collapsed into the smaller volume, and of the carbonic acid not yet altered. There is no difficulty here, therefore, in distinguished between the liquid and the gas. But in other cases the distinction cannot be made; and under many of the conditions I have described it would be vain to attempt to assign carbonic acid to the liquid rather than the gaseous state. Carbonic acid, at the temperature of 35·5°, and under a pressure of 108 atmospheres, is reduced to $\frac{1}{430}$ of the volume it occupied under a pressure of one atmosphere; but if anyone ask whether it is now in the gaseous or liquid state, the question does not, I believe, admit of a positive reply. Carbonic acid at 35·5°, and under 108 atmospheres of pressure, stands nearly midway between the gas and liquid; and we have no valid grounds for assigning it to the one form of matter any more than to the other. The same observation would apply with even greater force to the state in which carbonic acid exists at higher temperatures and under greater pressures than those just mentioned. In short, the passage under great pressures from the liquid to the gaseous state may be effected by the application of heat without break or breach of continuity. That a marked change in the physical properties of the substance occurs during this process is no objection to its being continuous. If mercury as a liquid is opaque and as a gas is transparent, the red and translucent bromine, on the other hand, when heated above the critical point, becomes so opaque as almost to resemble a mass of resin. Frankland has shown that the flame of hydrogen becomes continuous when the gas is burned under a pressure of 20 atmospheres, and these experiments have been since extended by the same able chemist and Lockyer. We must not, however, suppose that one intermediate state exists between liquid and gas; on the contrary, an infinite succession of intermediate states may truly be said to connect the liquid proper and the gas proper; in other words, the passage is continuous. When the critical point is attained, the density of the liquid and gas becomes the same, and the tube is filled with homogeneous matter.

As regards the question of the continuity of the solid and liquid states, it would be necessary, in order to establish this continuity, to obtain, by the combined action of heat and pressure, the solid and liquid of the same density and of like physical properties. To accomplish this result will probably require pressures far beyond any which can be reached in transparent tubes; but it may be possible to show by experiment that the solid and liquid can be made to approach to the required conditions.

INSTITUTION OF CIVIL ENGINEERS.

The Council of the Institution of Civil Engineers have awarded the following premiums for papers read at the meetings during the Session just concluded:—1. A Telford medal, and a Telford premium, in books, to Bernhard Samuelson, M.P., M. Inst. C.E., for his "Description of two Blast Furnaces, erected in 1870, at Newport, near Middlesbrough;" *2 A Watt medal, and a Telford premium, in books, to Jules Gaudard, C.E., Lausanne, for his paper on "The Theory and Details of Construction of Metal and Timber Arches;" 3. A Telford medal, and a Telford premium, in books, to Alexander Beazeley, M. Inst. C.E., for his paper on "Phonic Coast Fog Signals;" 4. A Telford medal, and a Telford premium, in books, to Thomas Dawson Ridley, Assoc. Inst. C.E., for his "Description of the Cofferdams used in the execution of No. 2 Contract of the Thames Embankment;" 5. A Telford medal, and a Telford premium, in books, to James Price, M. Inst. C.E., for his paper on "The Testing of Rails, with a Description of a Machine for the Purpose;" 6. A Telford premium, in books, to Walter Raleigh Browne, Assoc. Inst. C.E., for his paper on "The Strength of Lock Gates;" 7. A Telford premium, in books, to Sir Francis Charles Knowles, Bart., M.A., F.R.S., for his paper on "The Archimedean Screw Propeller, or Helix of Maximum Work;" 8. A Telford premium, in books, to Hamilton Ela Towle, of New York,

* Has previously received a Telford medal.

for his "Account of the Basin for the Balance Dock, and of the Marine Railways in connection therewith, at the Austrian Naval Station of Pola, on the Adriatic;" 9. A Telford premium, in books, to George Banks Rennie, M. Inst. C.E., for his "Account of Floating Docks, and more especially of those at Cartagena and at Ferrol;" 10. A Telford premium, in books, to Arthur Jacob, B.A., Assoc. Inst. C.E., for his paper on "The Disposal of Town Sewage;" 11. The Manby premium, in books, to Wilfrid Airy, B.A., Assoc. Inst. C.E., for his paper on "The Archimedean Screw for Raising Water."

The Council have likewise awarded the following prizes to students of the Institution:—1. A Miller prize to Frederick Harry Mort, Stud. Inst. C.E., for his paper on "Prussian Railways,—their Construction, Cost, and Financial Results;" 2. A Miller prize to George Gatton Melhuish Hardingham, Stud. Inst. C.E., for his paper on "Practical Aeronautics;" 3. A Miller prize to Arthur Turnour Atchison, Stud. Inst. C.E., for his paper on "The Theory of Energy, and its application in the form of Heat to the Steam Engine;" 4. A Miller prize to Henry Francis Joel, Stud. Inst. C.E., for his paper on "Bricks and Brickwork;" 5. A Miller prize to William Tweedie, Stud. Inst. C.E., and a Miller prize to Francis Wilton, Stud. Inst. C.E., for their paper on "The Calculation and Designing of Girders;" 6. A Miller prize to Henry Oliver Smith, Stud. Inst. C.E., for his paper on "Materials employed in Sewer Construction;" 7, A Miller prize to Killingworth William Hedges, Stud. Inst. C.E., for his "Description of the Pumping Machinery employed at the Works of the Amsterdam Canal."

SOCIETY OF ENGINEERS.

THE TIMBERING OF TRENCHES AND TUNNELS APPLICABLE TO RAILWAY AND SEWERAGE WORKS.

By Mr. Charles Turner.

(*Concluded from page* 164.)

There is another use of timber, which cannot be said to be confined strictly to cutting trenches for sewerage work, as it is applicable in all cases where masonry is carried on in deep excavations. It has been found more advantageous instead of carrying down the mortar in hods to supply the bricklayers to construct small trunks 5½in. square internally and about ¾in. thick; they are made out of stuff procured by putting two cuts through a batten and fitted with hopper heads. The lower ends are easily shifted, so as to deliver on to the mortar boards, the trunk being slung by a rope attached to short shear legs across the cutting. The mortar heap is made close by the cutting as the work proceeds, and one man filling the mortar into the hopper heads of two trunks can keep four bricklayers going instead of two, or even at times three, hodmen, who would otherwise be required, temporary shores and struts being used in some cases until the permanent shores can be driven. Where the ground is of the nature of running sand, and can only be excavated in very shallow lifts or stages, the excavation may be carried on after the manner in which square shafts are sunk and timbered in some of the German brown coal mines, upright pieces of half-round timber, pointed at the ends, being first driven into the ground, in advance of the excavation, and inclining slightly inwards. Waling planks are fixed between these timbers, and supported in a temporary manner by short piles, until the shores are introduced and driven from above as before-mentioned, care being taken always to have uprights under the waling planks. A space, varying in width from 2in. to 3in., will be left behind the waling planks, into which should be driven planks, or battens, or half-round pieces of timber pointed at the ends, and which pieces must be gradually driven downwards as the work proceeds as far as safety will allow, when another upright is driven down in front of the first in the same manner as already described, and shown in sinking short lifts through shifting ground, requiring to be close timbered. Great additional strength is given to this mode of timbering by introducing long binders of stronger timber from top to bottom of the excavation, taking a bearing against all the walings and having independent shores between them. This plan has also a great advantage in deep cuttings, where lias stone lime is used. The sliding of the mortar down the trunk keeps it chafed up and soft, instead of its constantly getting stiff upon the mortar boards when carried down in hods. It is of such great importance that the timbers used in shoring should be accurately fitted, that simple adjustable gauges, which do not easily get out of order, will always pay for themselves, such as may be made for taking angles and splays, and also for taking dead lengths at the same time. Although there are great objections to using iron bolts, screws, or spikes, to frame shoring together, there are cases where iron may be advantageously used in connection with wood, where shores have to be taken down, and replaced on the completion of each length of culvert. The ends quickly wear out, especially if they are driven horizontally, and the shores become too short. The plan was tried of shrinking iron hoops on to the ends of the shores, and was found to answer very well, and that there was a saving of one-third of the timber used in shores even in a length of 100 yards of culvert. Where the pressure is very great upon the shores they are very apt to split the waling, unless they are cut very accurately and are of the full size of the plank. It has been found of advantage to provide a few wrought iron clamps to use in such exceptional cases; they are fixed at the back of the shores. There is one more way in which iron may be used with advantage in connection with timber for shoring. It is frequently necessary to introduce additional shores at the bottom of a deep excavation for sewerage work, or to change the position of those which are fixed, to make room for the masonry. It is often very difficult to drive such additional shores into position, so that the proper pressure may be thrown upon them without disturbing several others. It is proposed to effect this object by making use of a double shore capable of adjustment in the length, and constructed in the following manner:—A piece of round timber 7in. diameter is hooped at both ends with strong wrought-iron hoops made from ⅜ths iron 4in. broad. A groove is then cut down the centre of the piece of timber 1in. wide, as far as the hoops at each end, with two cross grooves in the centre ½in. by ¼in. Folding wrought-iron wedges, with projecting ribs to fit the cross grooves, are then introduced in the centre, and driven up till the timber is sprung apart about 2in. or more, as the case may be, according to the length of the shore. Two other rings made of the same sized iron are then slipped over the ends of the timber, sufficiently large to go nearly as far the centre wedges. They are to be driven sufficiently tight to hold them firmly in their positions; the shore is then ready to fix in place. When in place the wedges are to be slackened, and the spring of the timber will cause the shore to fix itself tight without any hammering or wedging. When so fixed the loose rings are to be driven up against the wedges in order to prevent springing if an unusual strain is thrown upon the end of the shore. When the shore requires to be withdrawn the wedges are to be driven up again, and in so doing the loose rings are driven back, and the shore being shortened is easily removed. Cast-iron friction rollers working on wrought-iron pins are sometimes introduced with advantage at intervals instead of the wood rounds to the ladders used for conveying materials in deep sewerage trenches; they should of course be rather larger than the rounds. By carrying an endless rope round these rollers bricks may sometimes with advantage be lowered down in boxes instead of being carried down in hods. There are many other minor uses for timber for sewerage work, such as centreing, put together in pieces when common centreing cannot be withdrawn, temporary drainage trunks, and other items, which need not be particularly described.

Secondly, as to the use of timber in tunnel headings. The timbering when the ground is tolerably firm generally consists of two side posts, which are let 4in. or 5in. into the bottom. They should be inclined towards each other and framed into a head sill. When the ground is soft or shifting the side posts should stand on sole plates of half-round timber or short pieces of plank about 1ft. 6in. long. If it is of a still more shifting nature it is better to frame the posts into ground sills, either let into the bottom or framed together in a complete system of longitudinal and cross sills. When two sets of frames have been introduced at distances of from 4ft. to 6ft. apart, as the case may be, they are lined at the back with boards or planks, either at intervals or close together as may be required. Pieces of board pointed at the end, commonly called staves, are then driven above the head sill in the direction of the next frame; these should always be driven with a certain divergence outward, in order to make room for the introduction of the following set. This divergence is obtained either by cutting the board wedge-shaped, or by driving in slight temporary keys from the front between the boards and the head sill; or, better still, by introducing a lintel above the head sill, which is wedged up by two or more hard wood wedges against the ends of the boards. It is sometimes necessary to drive these boards also at the back of the side posts and under the sills, forming a close timbering, having the section of the frustrum of a pyramid. It is often also advisable, in order to assist in obtaining this divergence, to fix a third set of framing rather larger than the others in front of the second set, over or outside of which the boards are driven. The second set of staves is driven forward, in like manner overlapping the others to the extent of 5in. to 6in. If the stratum contains much water it is necessary to secure the face as the work proceeds. It is better in that case to proceed in steps by fixing short planks against the face of the work, and driving shores between them and the next frame, and if necessary strutting the frame against the one behind it. The poling boards and the boards forming the lining behind the side posts are then driven forward by degrees, sometimes only a few inches in the course of a day. Various temporary means of strutting and shoring the face are adopted, but these are so numerous, according to circumstances, that it is impossible to give any general rules for construct-

ing them. Experience and presence of mind are the principal guides to be relied on in such cases. Where it is necessary to carry a tramway through the heading the sleepers should be laid independently of the ground sills. The drainage from a heading should be carried in wood trunks laid upon the ground sills and under the cross sleepers carrying the tramways. These trunks should be made with a bottom and two sides tied together by cross pieces, dove-tailed into the sides of all the joints and intermediate ties, about 4ft. apart. The top should be loose, formed of short pieces with ledges under, of such a length that they may drop easily into their places, and may be lifted for the purpose of cleaning out the trunk.

In enlarging the tunnel from the section of the heading to the full size, very little timbering is required in an ordinary way beyond the centreing, as the masonry in all cases should immediately follow the excavation as it proceeds. There is always, however, a certain space to support in advance of the centreing, to allow room for the men to work in. This will often carry itself; at other times it is supported by short ends of boards, or planks resting on the masonry, and either shored or strutted against the face. A better plan would be to make use of an inner and outer centreing, the outer slightly overlapping the inner, and being strutted up from it. The front face of the inner or principal centreing should stand almost fair with the face of the outer centreing, but must not overlap it much, in order to give room for filling in round the outside of the arch. The two sets of centreing should be moved forward gradually as the work proceeds, and wedged up when in their places. The uprights should be of round timber; all tightening up should be done with wedges driven between the double plates. In some cases it is very desirable to construct the centreing so that it may be taken to pieces. A trussed centreing in three thicknesses is the most convenient description of centreing for the purpose. The outside segments of the centreing are cut in the usual form, and are jointed on the uprights; the uprights are shouldered to support the middle piece. The uprights and segments are tied together by wrought iron loops, which are riveted to the one segment, and, passing through a mortice in the middle segment and the outside segment on the other side, or the opposite upright, are keyed firmly against the upright or opposite segment by a hard wood wedge driven through the loop.

Then as to timber in shafts: in some cases a double curb of three inch plank, with the cross joints properly broken, is laid upon the ground, and the masonry being built upon it, it is gradually sunk into the ground, by excavating out the inside, and under the curb; various descriptions of iron bond being used to tie the masonry. For smaller shafts a common well curb is used, rather more strongly constructed than usual. Where timber is plentiful, and the conveyance of materials difficult and expensive, a square or rectangular shaft may be sunk and timbered in a similar manner to the shafts adapted for the mines in the Hartz Mountains. A strong curb of round timber is first laid, the timbers being halved together and slightly birds-mouthed, in order that they may fit to the rounded sides. When the ground is very full of water or otherwise insecure the curbs are laid one upon the other. At other times they are kept at variable distances apart, and are sometimes lined at the back with 2in. planks, but generally they are lined at the back with boards pointed at the ends, driven to a certain batter by the same means reversed as those described for driving headings, one set of boards always overlapping the next.

The long pump rods for deep shafts are generally of square timber, scarfed and bolted together, but where tapering sticks of round timber are readily available they will make an equally strong and much lighter and more economical pump rod. There are many other purposes for which timber is used in connection with tunnelling, as, for instance, the windlasses and horses whims for raising the stuff excavated, the ribbles or tubs in which it is raised, and the various timber erections and other buildings which are required in connection with the pumping and hoisting apparatus. These, however, vary so much that it would not be possible to describe them properly within the limits of an essay. It is sufficient to say that all framing should be well and strongly put together, and well tied with iron where it is in the open air, and all wearing parts should be of iron, or if that is not possible of very hard wood; and nothing should be so complicated as to prevent an intelligent miner from taking it apart and putting it together again. It is not for a moment supposed that anything new has been brought forward in the foregoing observations. An attempt has only been made to collect together a few memoranda from personal experience as a railway and sewerage engineer and contractor, and also the results of the information obtained while superintending some mines and furnaces in the Hartz Mountains, the timbering of which was carried out under the direction of a very intelligent and experienced German mining captain. Several of the modes of using timber above described were there executed under his superintendence at the suggestion of the author of this paper.

INSTITUTION OF ENGINEERS IN SCOTLAND.

ON THE HEAT-RESTORING GAS FURNACE, INCLUDING LATE IMPROVEMENTS AND ADAPTATIONS TO PUDDLING AND HEATING IRON, &c.

By Mr. Wm. Gorman, (Communicated through the President).

It is upwards of twelve years since the writer had the honour of reading a paper "On the Combustion of Coal" to this institution, in which was described a method of burning coal by converting the coke or solid part into carbonic-oxide gas, preparatory to its complete combustion. It was stated in that paper that "this power of transferring the great part of the combustion of the coal from the grate to the body of the furnace, together with the complete combustion of the coal gas promises to be of great use in the manufacture and working of iron."

This expectation has since been amply fulfilled in Siemens' regenerative furnace, and the heat-restoring gas furnace, the subject of the present communication. Reference is made, in the first place, to its application to the manufacture of iron. When it is considered that a ton of iron at the welding point contains only the amount of heat which is due to about 56lbs. of coal, and that usually 20 times this quantity is employed, it will appear that there is much room and much need for improvement in this department.

Such an enormous waste of fuel could not go on without some attempts to recover part of the loss, and hence, steam boilers were added to heating and puddling furnaces. For a long time, practical men opposed the measure, but the larger profits prevailed, and men have now got accustomed to work day and night within a few feet of magazines so dangerous that a few minutes' neglect or a trifling accident is attended with explosions, causing serious loss of life and destruction of property; and lately, in England, a whole work was levelled with the ground, and the most of the men killed by the explosion of a steam boiler placed amongst and heated by puddling furnaces. Now, any means by which this danger would be lessened should recommend itself to the ironmaster, even although no greater economy were realised, but when it can be shown that much greater economy and facility of production can be effected without materially altering existing arrangements, it is hoped that the inertia, or conservatism of habit will give way to larger profits, less danger, and greater production.

The heat-restoring gas furnace is designed to economise fuel by restoring part of the heat which escapes in ordinary furnaces, and it so happens that the arrangements necessary for this purpose are also admirably adapted for consuming the volatile gases of coal, thereby increasing economy and preventing smoke. It has been successfully applied in manufacturing iron, reheating for plate and bar mills, puddling, welding scrap, &c. In the shipbuilder's yard—forging and working plates, long angles, bars, &c.; it is also in use for boiler-makers, bridge builders, rivet and nail makers, and for enamelling and annealing, and has been so often erected in the neigbourhood of Glasgow, that only a very short description of it will be necessary. It is heated by combustible gases which may be supplied from any suitable source, but have hitherto been supplied from the ordinary coal or slack procured in the neighbourhood, and produced in apparatus attached to the furnace. The gas used for illuminating towns, and the gases escaping from blast furnaces, may also be used effectively and economically for supplying the requisite heat, so that it is not essentially necessary that the gas should be produced in connection with this furnace. The furnace, with its gas producer and heat restorer, occupies about the same space, and is arranged and worked in the same way, as an ordinary heating or puddling furnace, when applied to the same purpose; and, in addition to the usual damper, it has valves for regulating, admitting, or shutting off the air supplied for combustion as required. The gas producer occupies the same place as the grate room in ordinary furnaces, and only differs in being deeper, so as to allow, at all times, a thickness of over 2ft. of fuel on the grate bars: this provision is necessary to prevent carbonic acid gas from rising amongst the combustible gases, the presence of which, even in small quantities, prevents the combustion of the volatile gases of coal, and is in all cases deleterious, and cannot be too carefully guarded against. Although the difference between the gas-producer and the fire of the common furnace appears very little, yet it is very great, and it is most important that it should be understood and properly worked, or the furnace will not heat well or give its highest results. All that is required is to keep the bars clean, taking out clinkers only, but no coke or charred coal that can be avoided; fire often, and keep the fuel up level with the firing door or higher, at all times, and not to put much on at a time.

When the gas from the coal leaves the producer, carrying with it the heat generated there, it is supplied with air for its complete combustion, which, in this instance, it was found most convenient to introduce at

bridge, previous to its entering the heating chamber of the furnace where it produces a most intense heat, sufficient, if required for completely melting malleable iron, which indeed it has done several times and in large quantities. The air required for combustion is about 12 times the weight of the fuel; it becomes, therefore, a convenient vehicle for returning the heat which usually goes to waste. The more heat which can be imparted to the air supplied for combustion, the less coal is reqnired to maintain a given temperatnre in the furnace. The question becomes then—What is the best practical method of transferring the greatest amount of heat from the highly-heated waste products leaving a furnace to the air entering a furnace for combustion? The apparatus employed for this purpose is called a "heat-restorer;" it is based on a very elegant instrument to which my attention was first called by the late Mr. Condie. The instrument is for transferring heat and consists of two tubes, one placed within the other—the inlet of one tube adjoining the outlet of the other. The tubes are open at both ends. If hot water be poured in one tube and cold water in the other, the hot water will run out cold, and the cold water will leave the instrument heated very nearly to the temperature of the water which was poured in hot. The waste heat is transferred to the air for combustion by the restorer in the same manner. The air is introduced at the point farthest from the furnace, and gets heated as it advances towards it, where the gases are hottest; and, conversely, the hot waste gases, as they proceed towards the chimney, meet the air at its greatest heat first, and the temperature gets lower and lower as they proceed towards the chimney; by exposing great surface and continuing the process, the heat can be effectually restored to the furnace by heating the air.

The restorer is a chamber placed usually under the ground line, into which is placed a number of fire-clay pipes open at each end. A wall runs up at each end of the pipes, dividing the chamber into three compartments, one large in the centre, and one at each end of the pipes, into which they open, connecting the smaller end chambers. The flame, or waste heat from the furnace, passes downwards through the centre compartment, impinging on the outside of the tubes placed therein. The air for combustion enters the end space at the bottom, passes through the pipes to the other end, rising to a higher series of tubes, and recrossing till it arrives at the top of the chamber; the effect being an upward current of air meeting a downward current of heated gases, with only the thickness of the fire-clay tube between them: the current of air inside preventing the destrnction of the tube by the high temperatnre outside. The only extra about this furnace which has no counterpart in the common furnace, is the restorer, and in practice it gives no trouble. A set of restorer tubes has been worked regularly for two years, and when taken out for repairs, more than a half were fit for use again. Illustrations of a furnace in successful use are shown in Figs. 1, 2 and 3, for heating piles for rolling; it has heated six heats of 50 cwts. each, charged cold, in the shift of 12 hours; the bed of the furnace is 5½ft. wide by 7½ft. long, and as inspection of drawings will show the particulars of arrangement and construction. Appended are records of trials made to determine the loss of iron when heated in the gas furnace, compared with the common furnace. Returns of trials made at Govan Bar Ironworks in heating iron for a plate mill, to ascertain the exact yield of the heat-restoring gas furnace as compared with furnaces of the ordinary kind. The following are the trials referred to:—

Five piles, each 470 lbs. = 2,350 lbs., were weighed for the purpose and charged into the gas furnace. At the same time the same number of piles of equal weight were charged into an ordinary furnace. The gas furnace prodnced from 2,350 lbs. iron charged, 2,247 lbs. rolled iron, the loss being only 103 lbs., or 4·38 per cent. of the iron charged. The ordinary furnace produced from 2,350 lbs. iron charged, 2,058 lbs. rolled iron, the loss being 292 lbs., or 12½ per cent. nearly. The yield, or iron, required to produce a ton of rolled iron is therefore:—

	Ton.	Cwt.	Qrs.	lbs.
With the gas furnace	1	0	3	19
With the ordinary furnace	1	2	3	10
	0	1	3	19 less loss.

So that in the gas fnrnace 1 cwt. 3 qrs. 19 lbs. is saved, or less iron is used in producing a ton of rolled iron than with the ordinary furnace. These results were confirmed by subsequent trials; the returns of each are within a fraction of the above statements. The furnace has been worked regularly, heating three piles, each 1,400 lbs. = 4,200 lbs. per heat; and four heats within 12 hours, four heats of 4,200 lbs. = 16,800 lbs. = 7 tons 10 cwt., which, according to the above data, if heated in the gas furnace, would produce of rolled iron 7 tons 3 cwt. 2 qrs. 10 lbs.; and 7 tons 10 cwt. heated in the ordinary furnace would produce 6 tons 11 cwt. 1 qr. 11 lbs.; consequently, 12 cwt. and 27 lbs. of iron is saved by the use of the gas furnace in twelve hours.

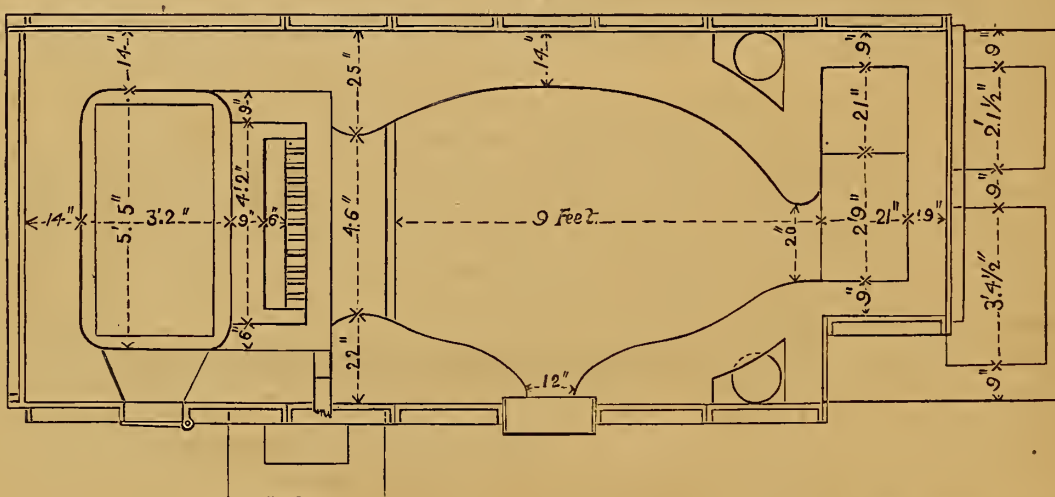
A more extended series of trials was made by the Mossend Iron Company, to compare the waste of iron in the heat-restoring gas furnace and that of the common furnace. Seven heats were charged in succession in the common furnace No. 5: the iron was in piles for large angle bars; the weight delivered

was— ....211 cwt. 3 qrs. 7 lbs.
was returned..................190 „ 3 „ 0 „ loss, 21 cwt. 0 qr. 7 lbs.

The yield was therefore 22 cwt. 2 qrs. 10 lbs., or a waste of 2 cwt. 2 qrs. 10 lbs. in producing a ton of angle bars. There was charged at the same time, and of the same weight and quality of iron for the same order, seven heats in succession into No. 7 (gas furnace)—delivered, 212 cwt. 0 qr. 7 lbs.; returned, 195 cwt. 2 qrs. 0 lbs.; loss, 16 cwt. 2 qrs. 7 lbs.; the yield was therefore 21 cwt. 2 qrs. 21 lbs., or a loss of 1 cwt. 2 qrs. 21 lbs. in producing a ton of angle bars—showing a saving in iron by the gas furnace of 3 qrs. 19 lbs. per ton of iron produced, including croppings; but the saving is higher when estimated on finished iron, as of course it must be, to get a commercial result. Now, in producing 16 tons of finished iron, 20 tons of iron require to be heated, and when the loss on 20 tons charged is estimated on 16 tons finished iron in each case, the saving of the gas furnace in the above instance is 1 cwt. 0 qr. 7 lbs. per ton of finished iron.

The next comparative trials were made at the works of the Lancefield Forge Company. There were two gas furnaces erected there, and from various causes they were not worked to a successful issue, and finally

Fig. 1.



abandoned, to the loss of the firm, and that of the writer. The following were the results obtained, and it is to be observed that one of the gas furnaces did not work properly, so that only the results from one furnace are recorded. In a day's trial of two common furnaces, 276 cwts. scrap delivered, returned 235½ cwts. welded iron, so that the yield, or scrap, necessary to produce a ton of welded iron was, 23 cwts. 1 qr. 21 lbs.—3 cwts. 1 qr. 21 lbs. being waste. In three days' trial with the gas furnace, 353 cwts. scrap delivered, returned 319 cwts. welded iron, the yield was therefore 22 cwt. 0 qr. 14 lbs.—22 cwt. 0 qr. 14 lbs. from 23 cwt. 1 qr. 21 lbs. = 1 cwt. 1 qr. 7 lbs. less waste per ton of iron when it is welded in the gas furnace.

The next trials for comparing the common and gas furnaces were made by Messrs. Colville and Gray, Coatbridge, who weighed the materials during a week's work of the gas furnace and two common furnaces; the results are as follows:—

	Charges of Puddled Bar.				Finished Iron and Croppings.				Puddled Bar, per ton of Finished Iron.			
	tons	cwts.	qrs.	lbs.	tons	cwts.	qrs.	lbs.	tons	cwts.	qrs.	lbs.
Common furnaces, each	58	2	0	14	53	5	0	14	1	1	3	25
Gas furnace	55	10	2	14	52	10	3	14	1	1	0	17
Saving per ton of iron, ...									0	0	3	8

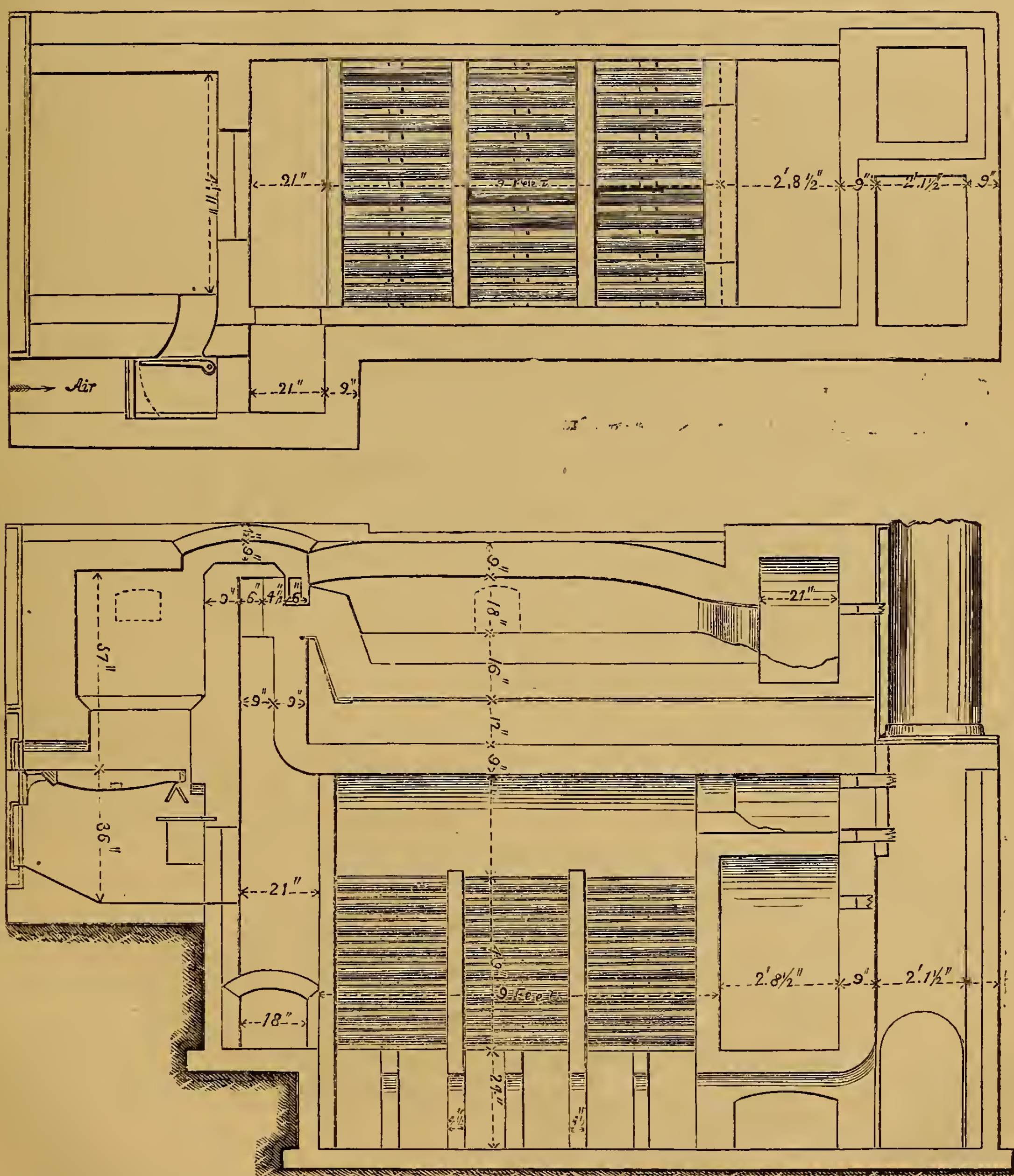
Coal.

	tons	cwts.	qrs.	lbs.		tons	cwts.	qrs.	lbs.
Old furnaces, each . .	25	17	0	0	per ton...	0	9	2	23
Gas furnace	12	7	0	0	,, ...	0	4	2	25

Saving per ton, 4 cwts. 3 qrs. 26 lbs.

Estimating the above yields in finished iron, without cropping, allowing five tons charged to finish four tons, then—

Fig. 2.



	tons	cwts.	qrs.	lbs.		tons	cwts.	qrs.	lbs.
Common furnace yield ...	1	1	3	25	× $\frac{5}{4}$ =	1	7	1	24
Gas furnace yield	1	1	0	17	× $\frac{5}{4}$ =	1	6	1	21
Saving on finished iron per ton...							1	0	3

The following trials of a gas puddling furnace and two ordinary furnaces took place at the Clifton Ironworks, Coatbridge:—

Nos. 15 and 19 common furnaces. Fuel coal.

	tons	cwts.	qrs.	lbs.			
Iron delivered	25	8	3	14	tons 36 cwts. 11 qrs. 0 at 5s. 3d. = £9 11s. 11d.		
Puddle bar produced	23	4	2	0			
Loss......	2	4	1	14	Yield per ton...	1 ton 1 cwt. 3 qrs. 18 lbs.	
Puddle bar produced	23	4	2	0			
Scrap used............	0	6	0	9			
	23	10	2	7	÷ 36 tons 11 cwts. 0 qrs. = 31 per ton of pd. bar		

Cost of coal per ton of puddle bar $\frac{£9\ 11\ 11}{23\ \ 4\ \ 2\ \ 0}$ = 8s. 1$\frac{3}{4}$d. per ton.

No. 13 gas furnace. Fuel dross ... 12 tons 14 cwts.

	tons	cwts.	qrs.	lbs.		
Iron delivered	11	17	0	21	Coal ...	0 tons 12 cwts.
Puddle bar produced	11	10	0	0		
						13 6 = £1 15 1
Loss......	0	7	0	21	Yield per ton	1 0 2 14
Puddle bar produced	11	10	0	0		
Scraps used	0	4	0	21		
	11	14	0	21	÷ 13 tons 6 cwts. = 22$\frac{3}{4}$ cwts. per ton.	

Cost of fuel, £1 15s. 1d. = 3s. per ton of puddle bar.

The saving is, therefore, in this instance, in iron, 1$\frac{1}{4}$ cwts. at 5s. = 6s. 3d.; and in fuel, 5s.; in all, 11s. 3d. per ton of puddled iron. At this time the workmen stated that they would as soon work the gas as the common furnace.

The following trials of a gas furnace for welding scrap were made by Messrs. Gray and Wylie, Coatbridge, and they mention in their note that "the scrap used in these trials was all old scrap from a broker's yard; had we used new scrap of our own make, the waste would have been much less. It will be observed that triping coal was used in the heats: we are in the habit of using dross, but in this instance were disappointed in getting it in: we find dross does the work equally well, and takes very little more weight than shown." The trial was done in 9$\frac{1}{2}$ hours.

Scrap Iron Delivered.				Bars Received.				Total Scrap Delivered.				
tons	cwts.	qrs.	lbs.	tons.	cwts.	qrs.	lbs.		tons	cwts.	qrs.	lbs.
1	0	2	0	0	17	3	8		5	0	2	4
0	18	3	22	0	17	0	7	Returned...	4	9	3	5
0	19	3	16	0	17	3	21					
1	0	3	26	0	18	3	4	Total waste	0	10	2	27
1	0	0	24	0	18	0	21					
5	0	2	4	4	9	3	5					

Then, if the yield on 4 tons 9 cwt. 3 qrs. 5 lbs. be 5 tons 2 qrs. 4 lbs., the yield for 20 cwt. will be 22 cwt. 1 qr. 10 lbs.

The only example of yield when heating small scrap is that of the Lancefield Forge Company already stated, comparing which with that here given it stands thus:—

	cwts.	qrs.	lbs.	
Yield of common furnace	23	1	21	scrap, per ton of welded iron.
" gas furnace	22	1	10	" "
Saving of welded iron	1	0	11	per ton, over common furnace.

Triping used in the above trial was 1 ton 3 cwt., or 4 cwt. 2 qrs. 3 lbs. per ton of scrap delivered.

The next trial is one shift of two gas furnaces in the works of Messrs. Gray and Wylie, Coatbridge, employed heating piles for rolling tyres:—

Iron delivered, 19 tons 9 cwt. 3 qrs. 4 lbs.; returned, 18 tons 6 cwt. 0 qr. 21lbs.: waste, 1 ton 3 cwt. 2 qrs. 11 lbs.: the yield, or iron, required to produce a ton of rolled iron is 21 cwt. 1 qr. 4 lbs.: the coal (triping) used was 64 cwt., being = 3 cwt. 1 qr. 27 lbs. per ton of rolled iron. The common furnaces for heating iron have all been taken down in the above works, and gas furnaces built in their stead, so that the above trial indicates the ordinary work of the furnaces when they are at this class of work.

Statement of two weeks' work of four of Gorman's heat-restoring gas furnaces at the works of Messrs. Gray and Wylie, Clifton Iron Works, Coatbridge, employed heating iron for rolling mills:—

16-inch Merchant Mill.

1871.	tons	cwts.	qrs.	lbs.
April 3rd, day shift	15	12	2	0
" 3rd, night "	11	3	2	0
" 4th, day "	14	13	3	14
" 4th, night "	15	11	0	14
" 5th, day "	14	7	3	21
" 5th, night "	14	12	2	0
" 6th, day "	12	19	3	21
" 6th, night "	15	7	3	7
" 7th, day "	12	6	1	0
" 7th, night "	13	12	0	0
" 8th, day "	12	17	0	14
First week	153	4	0	7
April 10th, day shift	17	13	1	14
" 10th, night "	12	18	3	0
" 11th, day "	12	13	1	0
" 11th, night "	11	11	1	21
" 12th, day "	16	11	1	21
" 12th, night "	15	3	3	7
" 13th, day "	13	18	1	7
" 13th, night "	11	16	2	21
" 14th, day "	14	10	1	21
" 14th, night "	13	17	0	7
" 15th, day "	13	16	2	14
Second week	154	11	0	21

	tons	cwts.	qrs.	lbs.
1st week	153	4	0	7
2nd "	154	11	0	21
	307	15	1	0

Total from 22 shifts from two furnaces being as near as may be 14 tons per shift.

18-inch Guide Mill.

1871.	tons	cwts.	qrs.	lbs.
April 3rd, night shift	10	9	3	14
" 4th, day "	12	1	3	14
" 4th, night "	13	7	3	0
" 5th, day "	11	9	0	7
" 5th, night "	13	11	0	0
" 6th. day "	10	19	0	7
" 6th, night "	11	18	0	14
" 7th, day "	10	16	2	7
" 7th, night "	14	0	3	7
" 8th, day "	9	1	0	21
First week	117	15	1	7
April 10th, night shift	12	2	0	21
" 11th, day "	6	19	3	14
" 11th, night "	10	7	0	7
" 12th, day "	11	15	1	0
" 12th, night "	10	7	3	21
" 13th, day "	11	11	1	0
" 13th, night "	11	13	3	7
" 14th, day "	12	8	3	21
" 14th, night "	9	19	1	0
" 15th, day "	12	3	1	0
Second week	109	18	3	7

	tons	cwts.	qrs.	lbs.
1st week	117	15	1	7
2nd "	109	18	3	7
	227	14	0	14

Total from two furnaces for 20 shifts being 11 tons 7 cwt. 2 qrs. 23 lbs. per shift.

Explanations regarding the foregoing Statement.

	tons	cwts.	qrs.	lbs.
The iron delivered for the 16-inch mill on the night shift 12th April was	19	9	2	4
The iron returned, including croppings	18	6	0	21
Loss in heating	1	3	2	11
Finished iron	15	3	3	7
Croppings	3	2	1	14
The iron was carefully weighed, and also the coal used, which was triping, and amounted to ...	3	4	0	0
From the above data, the puddle bar required to produce a ton of rolled iron amounts to	0	21	1	4
The coal (triping) necessary to heat a ton of iron ...	0	3	1	27
The finished iron from 16-inch mill was	307	15	1	0
Do. do. including croppings	362	0	0	0
Iron charged cold into the furnace	395	0	0	0
The finished iron per shift averaged	14	0	0	0
Do. do. including croppings	16	9	0	0
Iron charged cold per shift	18	0	0	0

Those figures include the usual stoppages and drawbacks incidental to a rolling mill, such as changing rolls, cobbles, and different sizes of iron, which accounts for the weight varying from 11 to 17 tons per shift. From all the various reports of trials received from different works, the saving is over 1 cwt. per ton of finished iron from the use of the gas reheating furnace, and the price of the coal does not amount to one-fourth of that of the ordinary furnace.

Experience shows that the gas furnace is more easily worked and more easily kept in repair, and that it will do a third more work with about half the weight of dross that is required in coal with the common furnace, but the peculiar feature of the gas furnace is the non-oxidising quality of the flame compared with that of the common furnace. When iron is welded in the flame of the common furnace, it is more or less oxidised or burned, depending on the amount of surface exposed, and when iron is thus heated its strength and tenacity is seriously impaired, and when it is overheated in the common furnace it is simply "burned," and any means by which such a contingency can be prevented or ameliorated ought to be adopted, more particularly in forgings, on the strength and tenacity of which depends human life, and it will materially add to our economical resources when the engineer can depend on the intrinsic quality of his material, and not be compelled to resort to mere bulk and weight for safety. The late David Elder's rule was to make the article six times heavier than it was usually considered necessary, and this practice of his prevented those dreadful calamities which occasionally startle society. If means are not at command whereby this deterioration of iron can be prevented, should they not be sought for? The writer believes they are supplied in the gas furnace when properly worked, and would remark, that when iron has parted with the most of its impurities, it is then in the most critical condition for being oxidised or burned. While impurities are present, they, to a certain extent, by their oxidation, save the iron; but, afterwards, each time it is heated in the common furnace, it is exposed to free oxygen, and consequently loses its substance, strength and tenacity, till at last it arrives at its normal state of an oxide or ironstone, and this is not a remote contingency, as a ton of scrap iron heated six times in the common furnace oxidises a ton of iron to cinder.

Oxygen is the great enemy of iron as a metal, and the object to be aimed at in heating iron is to produce the heat with as little oxygen as possible. The writer has discussed this subject in former papers, showing that the flame of the common furnace contains a large amount of free oxygen, which burns the iron less or more, but when additional air is supplied to such a flame, as has been occasionally done, the chemical results must follow, viz.: the oxidation or burning of the iron less or more. His endeavours have been to obviate such a state of things, and the heat-restoring gas furnace presents those means in the most advantageous and practical form. Economy in iron and fuel and facility of production are proved by the above practical trials to be greatly in favour of this furnace.

The writer has introduced a new form of puddling furnace, which has undergone several modifications in accommodation to circumstances. There was no difficulty in obtaining heat, but puddling is not a mere question of heat; and after many trials, the existing arrangement is believed to be adapted to all the conditions necessary in the puddling process. Many very favourable results have been obtained from trials of former modifications. The flame travels all round the furnace, and escapes at a port adjoining that where it enters the furnace; thence it passes under an oven or retort in which the coal is placed, so that the waste heat is caused to coke the coal previous to passing to the restorer, thereby producing a hotter and purer gas, and at less expense of coal. By this means the flame is also cooled a little, so that it is not so severe on the tubes as it was found to be when passing direct from the puddling chamber of the furnace. It will be observed that the tubes are placed behind the furnace in this instance. This was found necessary in order to allow the furnace to cool quicker for fettling, and to keep the puddling stance cooler. The method of returning the flame in the furnace was modified from an arrangement in which the flame was caused to circulate in vertical planes, the flame passing out of the back of the furnace. It is named the "whirl flame" furnace from the action of the flame. It is worked with dross a saving in fuel of 10 cwts. per ton of puddled iron, and a saving in the yield of iron of at least a half cwt. to the ton has been obtained at the Clydesdale Iron Works, Holytown, where 12 puddling furnaces are working on this plan. The method of returning the flame now adopted in the puddling furnace, has been found to heat a third more iron with 15 cwts. dross per day, than was done formerly by a common furnace with 28 cwts. splint coal; the repairs are reduced by one-half. The puddling furnace is now being rapidly developed; and there is no doubt as to its realizing as large an economy as the heating furnace, the effect of which will reduce the price of making malleable iron about 20s. per ton.

The system of coking coal or carbonaceous minerals by the waste heat of a furnace, is included in a patent granted the writer in connection with smelting and others furnaces, and great expectations have been raised by a very partial application of the principle to a blast furnace at the works of the Monkland Iron and Steel Co. It has been denied by our greatest authorities that the economy there obtained is due to the coking of the coal by the waste heat of the furnace applied externally, but it as been found to be a great improvement in the puddling furnace. There has not been time for trials so as to give proofs; but when it has been properly developed, there can be no doubt that it will be a considerable saving in fuel, and improvement in the working power of the furnace.

ROYAL UNITED SERVICE INSTITUTION.

ON THE NECESSITY FOR A PERMANENT COMMISSION ON STATE SCIENTIFIC QUESTIONS.

By Lieut. Col. A. Strange, F.R.S.

The duty of the Government with respect to science is one of the questions of the day. No question of equal importance has, perhaps, been more carelessly considered and more heedlessly postponed than this. And, now that a hearing has been obtained for it, neither the governing class nor the masses are qualified to discuss it intelligently; the governing class, because it is for the most part composed of men in whose education, as even the highest education was conducted 30 to 50 years ago, science occupied an insignificant place; and the masses, because they may be taken to be virtually destitute of scientific knowledge. Those who wield, and those who confer, the power of Government being alike incapable of dealing with this question, it devolves on another section of the community to urge its claims to attention. A tangible acknowledgment of the claims of science consists in the recent appointment of a Royal Commission "On Scientific Instruction and the Advancement of Science," which is now sitting. The problem which this commission is expected to solve is one of very great complexity, delicacy, and difficulty. It has to survey the whole world of scientific thought, and to construct a chart on which the districts that it is the duty of the State to occupy shall be clearly delineated, with boundary lines so drawn as not to trench upon tracts which may be best left to individual or corporate management. It has then to devise a form of Government of which not a trace at present exists, fitted to administer the affairs of the newly-acquired territories. It will be for the Royal Commission now sitting to point out the relation of instruction to investigation, and to decide how far, and by what agency, the Government may beneficially aid each. The first report of the Royal Commission has been published. It deals with certain limited matters of detail only, relating to the occupation of some new buildings at South Kensington. Possibly the settlement of these details may have claimed immediate attention with reference to the arrangement of the buildings in question. This first report has, therefore, not touched the great problems above adverted to, which await the deliberation of the Commission, and an authoritative solution of which at his hands is anxiously expected by the scientific world. It may be asked why, as a Royal Commission is investigating the relation of science to the State, the subject of the present paper should be brought forward independently of that body. The reply is, first, that discussions of any of the questions on which the Royal Commission is deliberating can hardly fail to afford light and assistance useful to the inquiry; secondly, that the problem submitted to the Royal Commission is, "How should the State aid science?" whereas the ques-

tion on which I am to address you is totally different, namely, "How can science aid the State?" Although this latter questiou may be considered by the Royal Commission, it is certainly not necessarily a part of their programme, and, as it is a question of at least equal importance with the former one, it is most undesirable that it should be overlooked. To the question, "How can science aid the State?" I reply, "By means of a permanent scientific commission or council, constitnted for the purpose of advising the Government on all State scientific questions." In order to apprehend the aim of this proposal, its practical operation aud probable results, it must be examined systematically aud in detail. I propose to do this under the following heads:—1. The scope implied by the term State scieutific questions, and the importance of those questions. 2. How are such questions at present dealt with, and with what results? 3. What should be the constitution and fuuctions of the proposed conncil of science? 4. What objectious can be raised against the proposed council?

1. The scope implied by the term State Scientific Questions, and the importance of those Questions.

In this term I inclnde, first, everything relating to the constructiou of ships of war, and of their armaments, ammunition, and equipmeuts—to naval sanitary arrangements, and to the employment of the naval service on explorations and scientific researches generally. I include, secondly, everything relating to military ordnance, small arms, ammunition; to army equipments of all kinds, to the sanitary arrangements of barracks aud hospitals, to the construction and protection of fortifications, and to the employment of the army for purposes tending to advance purely scientific knowledge. And I include, thirdly, all those questions of science which affect the civil life and well-being of the community, snch as drainage, sewage, ventilation, contagion, telegraphy, meteorology, astronomy, surveys, and the physical sciences generally, so far as they are promoted by the Government. Many fiscal and commercial questions of great importance, which have a scientific basis, mnst also be included. I have not attempted to specify all the scientific questions that come, or should come, before the Government of a civilised country. They are almost innmerable, and their simple enumeration wonld occupy the whole of my available space. They may all be comprised under the three great divisions—uaval, military, civil. As to their importance, what need be said? Are an efficient navy and army important? Are the health and welfare of the community important? And, if they are, then let me ask, have we an efficient navy and army at this moment? Have we ships of war that command the confidence of sailors? Is our naval ordnance beyond any improvement? Are our land artillery and onr military small arms perfect? I wish to avoid exaggeration. I will not say, as some do, that all these things are, with us, execrably bad; I will not even say that in many of them we are behind other nations; my case does uot require the support of such extreme opinious. I shall, I believe, be able to maintain my ground by the statement, which few will attempt to controvert, that practical and well-iuformed men consider all onr naval and military armaments, eqnipments, and ammunition to be susceptible of improvement, and that such improvements can, in most cases, be effected only by attention to scieutific priuciples. I mnst add to this another opinion, in which all competent judges will concur, that so long as human knowledge advances, in other words, so long as the world lasts, there will be an incessant demand for improvement in these things. The importance of civil and social questions into which science enters is at least as great as that of the questions to which I have adverted. If it is important that a community be protected from foreign invasiou, it is equally important that the health, welfare, and commercial and intellectnal progress of the community, for whose beuefit costly naval and military forces are kept up, should receive due attention. We have witnessed au example on the grandest scale of the successfnl application of science to war so recently, that before a naval and military audience it mnst be quite unnecessary to dwell upon it. But these events have confirmed a conviction previously held by many who had seriously studied such subjects, namely, that in the preseut stage of human progress science is indispensable to national greatuess, that the arts cannot flourish, trade cannot prosper, knowledge cannot advance, war cannot succeed with a nation that neglects science. Other things also are necessary, a strong, just, and wise Government, constitutional and religions freedom, love of order, and respect for the laws. Without these, also, there cannot be national greatness, but, even with these, the nation that is not foremost in science cannot be foremost in civilisation. Assuming these questisns to be sonnd, it is no rash assertion to say that "Stato scientific questions" are of immeasurable importance.

2. How are such questions at present dealt with, and with what results?

How then are State scientific qnestions now dealt with? The answer is, desultorily, capriciously, inefficiently, irresponsibly, when they are dealt with at all, but in many instances of the greatest moment they are absolutely neglected. The nnmber of questions involving science on which Government has to decide are innumerable and never ending. Every day adds to their number and their urgency. What are the official arrangements by means of which the administration of the day can successfully apply the discoveries of science to the developing and perfecting of our naval and military appliances, not to speak at present of the multitndinous wants of civil life that clamour for attention? The reply is that our official arrangements are snbstantially the same now as they were in the pre-scientific era—they may be more exteusive in degree, but they are the same in kind—the bntter may be spread further, bnt there is not more butter. The enormous scientific activity of the last 30 or 40 years does not seem to have struck the official world as a fact having a bearing on the humdrum routine of the departments. More secretaries, more clerks, more subordinates of various kinds have been appointed to prevent accumulation of arrears; more committees of iuquiry have sat, more scientific witnesses have been examined, more reports published, if not read; but not a single step has been taken towards the creatiou of an organisation capable of concentrating and directing all this scattered effort. The example of foreign nations, the pressure of the public, aud the demands of inventors, daily set before the Government scientific puzzles, which they are often, if not generally, at their wit's eud to solve. It never seems to occur to them that these pnzzles will never cease, and that they will increase in difficulty as a matter of absolute certainty. The attempt is made to stave off by temporary expedients work of a permanent character. The puzzles are guessed at, and the guess is oftener wrong than right. Problems too deep for guessing are either pushed out of sight or submitted to methods of iuvestigation that end in a blunder, perhaps a catastrophe. I will briefly indicate the provision that does exist for the solntion of State scientific questions. It is of three principal kiuds. First, official snbordinates in various departments. Second, temporary and special committees. Third, consultation with individnals eminent iu science, or with scientific bodies. I omit debates in Parliament because no scientific question ever was or will be solved by such an assembly; and I omit also the press, which is so inflnential in other respects, as altogether unreliable for such inquiries. The objections to the first kind of provision, viz., official subordinates, are that snch persons have almost invariably other duties of an executive nature to perform, and have not, therefore, the leisnre necessary for scientific iuvestigatiou. Science, moreover, is now in a stage in which scarcely any one problem can be adeqnately grasped by a single miud; this remark particularly applies to State scientific problems, which are invariably of a mixed order, requiring a great variety of attainments for their perfect comprehension. Lastly, subordinates are disqualified for the office of advisers by the very fact that they are subordinates. No inferior can be expected to urge distasteful counsels on a powerful superior; aud no snperior can be expected to abandon his own preconceived ideas in consequence of the timid and feeble remonstrances of au inferior uuder his orders. Subordinates, then, are unfitted to be counsellors, because they must in the majority of cases be deficieut in leisure, attainments, and independence. One clear, decided example of the inadeqnacy of this source of scientific advice is as good as a thousand. There can be no more opposite example than that of the ill-fated ship *Captain*. The desigu of this ship came from without. Captain Coles, though a naval officer, must be considered as a typical indepeudent inventor. He urged his ideas on the Admiralty by every available moans, by papers and lectures at this and other institutions, by articles and letters in the public journals, and by interpellatious in Parliament. He was, no doubt, actuated by excellent motives. He was of a most ingenious turn of mind, and had a very persevering, energetic nature. But no one has said that he was a man of science. It was perfectly well known to those who knew him at all that he was nothing of the kind. His invention were precisely of that order that required strict scientific investigation. They were novel; they involved complex aud even contradictory conditions, and they touched the most vital iuterests of the nation—her uaval supremacy. So difficult is the problem which they represent, that, although perhaps no such problem ever nnderwent so much anxious and able investigation, no generally-accepted solution of it has yet been arrived at. This tremendous issue was left in the hands of the Admiralty and its subordinates. We know with what result. It is not my purpose to fix the blame of that resnlt on any individual. It has not, in my opinion, indeed, been brought home to any one in particular. But there stands this indisputable fact, that the most recent specimen of English naval architecture, given to the nation under the auspices of the Admiralty aud its advisers and subordinates, went to the bottom in an average squall. It is idle to say that no responsibility rested in this particular case on the Admiralty officials. One thing of three must have happened. Either the design was not thoroughly investigated by the Admiralty snbordinates; or, if investigated, it was not objected to by them; or, if objected to by them, their advice was disregarded by their

superiors. Whichever of them was the true cause, the imperfection of the system is equally established. The Admiralty wished to adopt Captain Coles's design, and either the knowledge or the authority necessary to prevent so fatal a mistake was wanting. Can it be for a moment snpposed that had an established, competent, and independent adviser of the Government pronounced an authoritative "No," any minister that ever lived would have dared to act in opposition thereto? But there existed no such adviser, and the ordinary official advisers were either supine or overridden; for the purposes of my argument it matters not which.

The second expedient, temporary committees, has been very largely employed for the purpose of guiding the Government through their scientific difficulties. There are very serious objections to this expedient. First, there seems to be no rnle either for their appointment or for their composition. If the government is much pressed by public opinion (which on such subjects is not over-well informed), or if it sees a difficnlty a-head, which, however, it often fails to do, a committee is the resnlt. But there is no guarantee for the proper composition of the committee. There always lurks about some of the names a suspicion either of incompetence or of leaning towards the snpposed foregone conclusion of the Government. Bnt, passing by these suspicions, there remains the fact that the members are selected either by some minister who, not being a scientific man, probably knows nothing about the qualifications necessary for conducting the proposed inquiry, or by some ontside and irresponsible person to whom the minister has applied for help. It is quite overlooked that the selection of the proper persons for conducting any given inquiry can only be made by some one having a knowledge of the subject of the inqniry or subjects cognate thereto; the selection is in itself a scientific qnestion. Though some temporary committees have done good service, it may be safely declared that, on the whole, they have failed to give reasonable satisfaction. A second objection to such committees consist in the fact itself that they are temporary. As such they necessarily commence their labours, however well they may have been selected, with but a partial and confnsed knowledge of the questiou at issue, and much time is lost in gaining some insight into it. After much work and expense, they reach a certain stage in the inquiry at which a report is possible. Perhaps by that time the public pressure or other cause that led to their appointment has died out, or action is necessary; in either case, the committee is considered to have served its purpose, and is broken up, the members disperse, take np other duties, the knowledge of a particular subject which they gained in the course of their inquiry is lost to the country, and a scientific problem is left half-solved, until at some future day it must be taken up again for completion, and all the old work gone over *de novo*. The system of temporary committees, in fact, implies a belief that finality is attainable in those mixed scientific problems in which chiefly the State is interested, or that such problems can advantageonsly be taken to bits and studied piecemeal; whilst the fact is, that no one such problem that can be mentioned ever has, or ever will, as long as human ingenuity survives, come to an end. Permanent arrangements alone can deal with the unbroken continuity and unceasing change of scientific development. A third objection to such committees consists in the fact that much of the investigation carried on by several committees may be common to each. This involves the repetition of the same work, and great consequent waste of time, effort, and money, besides sometimes leading to perplexing contradictions in the respective results. This wonld be avoidable if the varions committees were subject to one common authority, and were instructed to avoid needless repetitions of the same or similar researches. Bnt no such common authority exists in England. Scientific committees work, therefore, as independently of each other as if their respective inquiries could be of no use to any but themselves. I now come to the third sonrce from which the government draws its scientific inspiration, namely, individnals eminent in scientific bodies. Recourse is had to such sources without any system whatever; there exists no rule, for instance, defining what cases should be submitted to an individual, what cases to a scientific society, and what cases to a temporary committee. Nor is it possible to assess the degree of responsibility attaching to an individnal or to a scientific society advising the government. If the advice so obtained is rejected, nothing about it is known publicly; if it is adopted, and turns out unsound, the right to blame the adviser is absent. It is impossible to ascertain when snch consultations have occurred, and with what results. The probability is that they are not frequent. During the two years that I served on the conncil of the Royal Society, I only remember one application from Government for advice. It was on some point connected with coppering ships. A committee was formed of the most competent persons, and probably very sound counsel was afforded. But it is evident that this is an expedient that cannot be frequently employed, as it would occupy too much of the time of the society, which should be devoted to its legitimate objects. Advising the Government is certainly not one of these, nor should the Government of a great, powerful, and opulent nation like England be reduced to make snch makeshifts as private societies for direction in matters of such tremendous national moment. Having shown, I trust, that Government is without recognised scientific advisers, I procced to discuss—

3. What should be the constitution and functions of the proposed Council of Science?

The ground requires to be cleared before approaching this question. I have heard it urged that the various departments of the State shonld be complete in themselves, each with its own consultative element as distinct from its executive. This appears at first sight a plausible arrangement, but it will not bear examination. Many of the scientific questions that devolve on the Government affect several departments, and in such cases it would be wasteful to have numerous repetitions of the same investigation when one would do; and if, under the supposed arrangement, one investigation of a given class of subjects was decided on, the selection of the particular department to which it should be referred would cause endless bickerings and jealousies, the co-operation of departments being, like universal peace, a somewhat remote hope. Again, several departments would require identical scientific advisers. For instance, few departments could dispense with a chemist; a number of chemists would have to be employed where one or two would snffice. And, further, it would be found necessary to provide for each of the departments requiring scientific advice representatives of several branches of science. The aggregate number of scientific advisers wonld be enormous if each department were independently efficient. Finally, such a system would not be homogeneons, and would be found very difficult to work practically, on account of the diversity of decisions that would occur on questions more or less identical. There wonld then arise, just what has now arisen, want of a final court of scientific appeal to reconcile discordances and give certainty to the action of the executive. For these reasons I discard this suggestion, and revert to the proposal which forms the subject of this paper, namely, that there should be one permanent great council for advising and assisting the Government on all State scientific questions. This council should be purely consultative, not executive. All departments should equally be entitled to its assistance. The council should not be expected to initiate qnestions, though it might occasionally see fit to propose certain investigation to the Government, without whose sanction, however, they should not be undertaken. The Government should not be bound on all occasions of scientific difficnlty either to resort to, or be guided by, the opinion of the conncil, but it would, of course, become in either case absolutely responsible for all consequences. The proceedings of such a body would embrace a vast field. Since there is no branch of science with which the government does not, at some time or other, come in contact, every well-defined branch of science shonld be fully represented on the council. There would reqnire to be pure and mixed mathematicians, astronomers, surveyors, chemists, physicists, engineers, physiologists, physicians, surgeons, naturalists, geologists, meteorologists; for some of these subjects two or more representatives of their different subdivisions would be needed. The naval and military services of all arms and the commercial element shonld also be present. Probably not less than 50 members would be required for thorough efficiency. The Council of the Royal Society numbers 21 members, and this body takes little or no cognisance of naval and military questions, nor of those relating to public health, except indirectly, as illnstrating philosophical views. The council would conduct its business by means of working snb-committees, into which it would divide itself for specific purposes. The reports of such sub-committees should be snbmitted to the whole council for general discussion, and the responsibility for the advice ultimately tendered to the Government would rest on the council as a whole, not on the section or snb-committee with which it might have originated. This mode of working would insure dispatch of bnsiness, special aptitude in the investigators, and large views derived from a great variety of attainments and habits of thought. Decisions thus matured could not fail to command public confidence. The duties that would devolve on this conncil, stated broadly, would be:—1. To advise the Government on all qnestions arising in the ordinary routine of administration snbmitted to it by the varions departments. 2. To advise the Government on special questions, such as the founding of new scientific institutions, and the modification or abolition of old ones; the sanctioning of scientific expeditions, and applications for grants for scientific purposes. 3. To receive, consider, and decide npon inventions tendered to Government for the nse of the State. 4. To conduct or superintend the experiments necessary to enable it to perform the above duties. As to the first branch of its duties, little need be said. The nnmber and variety of questions involving scientific considerations entering into the current work of the different departments are almost unlimited. A large proportion of them could be answered at once by competent persons, but there would remain many

that would require investigation, discussion, and often experiment. The second branch, special questions, would not perhaps be so extensive, but it would be exceedingly important. At present there exists literally no provision for dealing with such questions. Sometimes one person, supposed to have a knowledge of the matter at issue, sometimes another is consulted, sometimes no one. At present the Royal Commission now sitting is probably dealing with the subject of existing and required scientific institutions. But supposing this body settles all such matters in the most satisfactory manner at the present time, a reconsideration of them will very soon be demanded by the rapid advance of science, and the perpetually changing relations of different lines and modes of physical inquiry. But the Royal Commission is a temporary body. Its functions will, sooner or later, cease, whilst the mutations and permutations of scientific thought are incessant. Questions relating to State scientific institutions require ceaseless watching—never-ending modification. A permanent body, such as I propose, alone can preserve the national scientific establishments in a condition of vigorous efficiency on a level with the existing state of physical knowledge. The sanctioning of special scientific researches and expeditions will be a very important duty, which there is at present no one qualified to perform. Last year, when the aid of Government was desired for the solar eclipse expedition, this want was strongly felt. The men of science went first to one department, and were snubbed by it; they then tried another, from which they did not receive even a snub, their communication being totally ignored. Ultimately, a private individual obtained by personal influence an interview with the Chancellor of the Exchequer, and succeeded in inducing that minister to sanction an object with which his particlar department had no concern. Had there been a department for science, none of this fumbling would have occurred; but as it was, the expedition was almost rendered impracticable by delay, and its object was only attained through the strenuous exertions of a few energetic private individuals voluntarily devoting their time to the purpose. Analogous to this is the case mentioned last year at a conference of the Society of Arts by Lord Henry Lennox, that recently "wishing to ask a question in the House of Commons as to the national collections, he found that, if he put the question at all, he must put it to four or five different members of the Government, and perhaps to one gentleman who was not a member of the Government at all. He therefore was obliged to put his question to the Prime Minister, as representing the collective wisdom of the Government, although those who really had to supply the answer were sitting around him." I question whether the state of things here described exists in any civilised country but our own. Sanctioning of grants of money for aiding scientific objects comes under the same head as sanctioning expeditions. At present, £1,000 per annum is granted by Government for such purposes, and it is distributed by the Government grant committee of the Royal Society. As a member of this committee, I can testify to the extreme care, fidelity, and impartiality with which it performs this gratuitous duty. The amount of the grant might with advantage be much increased, as at present only small sums can be given out of it to each applicant; these are often quite insufficient, and as they must unavoidably be small, no application for aiding extensive and costly researches can expect efficient aid from so narrow a source. The proposed council would be a public body, precisely qualified to perform the duty now imposed on individuals. The third branch of duties devolving naturally on the council would be the dealing with inventions tendered for the use of the State. Perhaps my views on this point will not lose force from the fact that I have never tendered inventions to the Government, and am not personally interested in any such. No duty which I propose to assign to the council is more important than this. At present the different departments are inundated with inventions which there is no one possessing both the needful qualifications and the requisite leisure to grapple with. They should be relieved of this oppressive labour and responsibility. It is quite notorious that both the departments and the inventors have great ground for complaint,—the departments because they do not possess machinery adequate to cope with the flood of inventions, and inventors because their proposals often do not and cannot receive fair attention. Inventions offered to Government may be classified under two principal heads—the mature and the embryo. The mature inventions require judgment to be exercised as to their acceptance or rejection—a contrivance good in itself may be unsuitable to the policy of the Government, or to the conditions with which it would, if adopted, have to be combined, as for instance, a particular kind of gun might not suit the class of ships then building. With this order of invention only a mixed body of professional and scientific men could satisfactorily deal. The second order—the embryo inventions—include every imaginable conception, from the utterly valueless crotchets of visionaries to germs of the most magnificent promise. Can any one pretend for a moment that we possess the means of sifting patiently and discriminatingly the heterogeneous mass of suggestive ideas that the most inventive people in the world are daily accumulating? The ordinary official view of the matter is, that individuals must be left to work out their own ideas. In many, perhaps in the majority of cases, that may be true, but now and then a suggestion may come from one too poor to work it out, which, if the powerful resources of the State were applied to it, would turn out to be of priceless value. Should we despise the pearl because the search for it is laborious? All inventions offered to the State should come before the Council of Science, who should advise the Government as to the adoption of some, and as to aiding in the development of others. The examination to which such a body would subject such proposals, though it would probably not satisfy each individual projector, would certainly satisfy the nation that this wide and creative sphere of its intellectual supremacy was receiving fitting attention. No such satisfaction at present is felt. Again, though many inventions are adopted by the State, the inventors do not always receive liberal treatment. At present, as the law stands, the State has a right to the free use of a patented invention, and this seems necessary. But the State properly admits that the proprietor of a useful patent thus adopted, should be remunerated. Theoretically that seems very fair, but practically the amount of the remuneration is fixed by the Government or by the department using the invention, and this amount is often niggardly in the extreme. If it were fixed by an independent and highly-qualified body like the proposed council, a nearer approach to an equitable arrangement of such matters would probably be arrived at. It is impossible to speak of inventions without suggesting thoughts of patents. I propose to say very little regarding these monopolies, because a discussion on our Patent-laws is very far from being the object of my present address. Though very divergent views are held on the subject, all are, I think, agreed that our present patent system is glaringly defective, neither affording to inventors due encouragement and security, nor to the community generally adequate legitimate advantages. The question how to improve this most unsatisfactory system is one of extreme difficulty, involving a multitude of nice legal points, and of equally subtle scientific considerations. The judges that the problem cannot be solved by themselves singly, and that special scientific aid must be afforded them. Where is this to come from? Whence could it come with such authority and impartiality as from the council, whose creation we are now considering? The fourth class of duties which the council would have to perform would relate to the experiments and investigations necessary to enable it to perform the duties previously enumerated. Regarding the necessity for providing the council with the agency, appliances, accommodation, and funds requisite for these purposes, there can hardly be two opinions. They are absolutely indispensable. I need not here attempt to define what would be wanted. Such details would follow naturally the affirmation of the great principle involved in the creation of the council.

I come now to a question on which opinions may differ, namely, the question whether the council should be paid or an unpaid body. I say, unhesitatingly, that it should be handsomely paid. If the heads of duties to be performed, of which I have given but an outline, be duly considered, it will be seen that they will be laborious, responsible, and beneficial in the highest degree, and that they can only be adequately performed by highly-qualified persons. It is idle to expect that such men as will be necessary will devote themselves almost exclusively, as they will have to do, to such labour from pure love of science and of their fellow creatures. The delights of philosophical speculation are one thing, carrying with them their own reward—a reward beyond any money consideration; downright official routine work is quite another thing. In no other professional field is it unpaid, nor is it ever worth much if not paid for. It has hitherto been too much the custom to treat men of science as exceptions to all other professions; to assume that whilst it is quite proper to enrich and ennoble soldiers who fight for pay, lawyers who evade or apply the law according to circumstances; physicians, who kill or cure as seemeth best to them, and even divines, whose mission to save souls might be deemed a sufficient privilege; the man of science, who contrives the arms with which the soldier won his fortune and his coronet, who surrounds the lawyer, the physician, and the divine with the luxuries which their superior privileges enable them to command, should work for love, and die, as he too often does, in poverty. If the council, the creation of which I now advocate, does its duty, it will confer benefits untold on every member of the community, from highest to lowest; from the military and naval appliances necessary to protect our unequalled national wealth, down to the smallest and least regarded necessaries of our ordinary life, the influence of this council will be felt; and is it either just or wise to expect such benefits for nothing? The salary that I should recommend as appropriate would be £1,500 per annum to each member of the council. It may be urged that there will be no guarantee that these offices will not become sinecures. Of course, neglect of duty may happen here as elsewhere; but care in selecting the members will afford some hope that they will be

men of honour; and, as a rule, true men of science are seldom idlers. But an incentive to work may be given by the principle adopted on boards of public companies, namely, payment according to attendance. I need not, however, dwell on such matters of detail. My sketch of the proposed council will not be complete without some indication of the mode of constituting it. The two characteristics which it is most essential to ensure are high qualifications, and the most entire freedom from political bias. The members would probably be of three classes:—1. *Ex-officio* members, being heads of certain existing State scientific institutions, such as the Astronomer Royal, the Director of the School of Mines, the Mint Master, &c. 2. Military and naval members. 3. Scientific members, not of either of the two first classes. Regarding, first, the *ex-officio* members, nothing need be said. The election of the second class might be initiated by that part of the corps to be represented then serving in England, as, for instance, the engineers, the artillery, or the navy. The arm of the service requiring a member should select four names; these should be sent up to the council, who should reduce them to two; and of these two the Government should be bound to appoint one, without power to reject either of them, or to substitute a nominee of their own. For class three, the scientific societies would form the best constituencies; and the election might be conducted in the same manner as that of class two—four names being at first selected by the society whose branch of science had to be represented, these reduced to two by the council itself, of whom one should be appointed by the Government. In this way each arm of the service or branch of science would be represented by a person in whom they had confidence; the council itself, powerfully interested in the efficiency of its colleagues, would have a voice in their election, and the Government would also participate to a moderate extent in the ultimate result. I do not give this as the only or the best form of election, but as one of many feasible forms by means of which an efficient body, from the suspicion of subserviency to the Government of the day, may be constituted. I come now to the last division of my subject.

4. What objections can be alleged against the proposed Council?

Difficulties innumerable can of course be conjured up in this as in every case of reform, but I have only heard three definite objections raised that seem to me to deserve any notice. They are:—1. That this is a system of centralisation, and therefore objectionable. 2. That it will be liable to jobbery. 3. That it will be too costly. I will touch on each of these briefly. As to centralisation, I admit the impeachment, but claim it as an advantage, not an evil. Those who are scared by centralisation forget that it constitutes the very basis of civilisation and of stable, efficient Government. In primitive, savage life there is no centralisation, no united effort for a common purpose. Each individual struggles single handed for his rights. Civilisation teaches us to set apart certain members of the community for purposes beneficial to the whole, to form them into distinct bodies, having definite duties, to be executed under the direction of a head central authority. The army, the navy, the police, the post-office, are examples of such bodies, the animating and ruling law of which is centralisation. In the case of the police, we have local, in the other cases imperial centralisation. The body we are considering will have to perform duties of a strictly imperial character, contributing directly to the efficiency of the defensive power of the empire, and to the security and well-being of every member of the community. It is a body which not only would not be effective, but which could not exist, but in a centralised form. As to the second objection, that the arrangement I have proposed would be liable to jobbery, I must own that, as I contemplate the employment of human beings only, I do certainly expect to see the operation of human motives. But if jobbery be a fatal objection to the scheme, then, on the same principle, we ought to have no army, no navy, church, bench, magistracy, municipalities, or parliament, for in each of these the discovery of some traces of jobbery will probably reward a diligent scrutiny. It is not apparent why a degree of purity not dreamt of in regard to any other profession should be insisted on when science is in question; nor is it clear why men of science should, *à priori*, be deemed more corrupt than their neigbours. Of course every precaution should be taken against corruption in so important a body, and the rest must be left to that sense of honour to be found in all other professions, and of which even men of science are perhaps not entirely devoid. The third objection, undue costliness, is, in my opinion, as invalid as the other two. My proposal has two main objects—to increase efficiency, and to diminish blunders. Both are in the strictest sense economical objects. If it does not seem calculated to attain these objects, it should on no account be adopted. If it gives satisfactory promise of their attainment, no expenditure that it is likely to occasion will be too great in order to secure them. Let any one who is terrified by the cost visit our ports, dockyards, and arsenals, and there see the ships that have been built which should not have been built, the cannons made that should never have existed, and the useless arms and equipments of the pre-scientific ages. Let him count the cost of these, and compare it with the probable cost of substituting for the reign of haphazard ignorance, a reign of systematic intelligence. To take one example, that of H.M.S. *Captain*. This vessel, with her armament and stores, probably cost the nation three or four hundred thousand pounds. Who shall assess in money the value of the 500 noble lives that perished with her? Would not the nation willingly give a million to have them back? If so, we have as the cost of one single blunder committed by one department something like a million and a half of money, a sum that would go a long way to permanently endow a body which, had it existed a year ago, must have prevented that blunder. But if I dwelt on the preservation, prolongation, and increased comfort of civil life which such a council would certainly tend materially to secure, the cost of its maintenance would appear absolutely insignificant in comparison with the blessings it would shower on the nation. Against the cry of costliness I oppose the assertion, easily established, that nothing is so ruinous as disregard of the laws of nature, and nothing so profitable as intelligent obedience to them. Science, looked at in the driest commercial spirit, must, in the long run, pay. I must guard myself against the supposition that the proposal I have here advocated comprises all that is necessary for the efficient administration of scientific State affairs. It is only one part of a great system that has to be created. Other parts of the system will, no doubt, receive due attention from the Royal Commission now considering them. But there is one part so important that I feel called on to name it—I mean the appointment of a Minister of Science. He need not necessarily be exclusively devoted to science; he might, perhaps, with advantage, have charge of education and fine arts also; but some one in Parliament, directly representing the scientific branches of the national services has become absolutely indispensable. Another urgent want which, as its scientific character is not purely physical, will probably not be dealt with by the Royal Commission on Science, is that of a high war council—a council of naval and military officers of the greatest professional attainments and distinction, constituted for the purpose of advising the Government on the highest problems of strategical science. At present we have not a vestige of anything of the kind, and are consequently, as a military nation, almost destitute of the basis of the military art. When we have all scientific national institutions under one Minister of State, advised by a permanent, independent, and highly-qualified consultative body; when we have a similar body to advise the Ministers of War and Marine in strategical science, then the fact that, in accordance with our marvellous constitution, these ministers must almost necessarily be men without pretension to a knowledge of the affairs which they administer need cause us no alarm. When these combinations have been, as they assuredly will be, sooner or later, effected, the wealth, resources, and intelligence of the nation, having due scope, will render us unapproachable in the arts of peace, and unconquerable in war, but not till then. My proposal, therefore, I maintain, aims at the creation of no new principle, but only at the extension of one already existing, and universally approved after long experience. Nor do I aim at creating new labours. The work of which I have been speaking is now being done, or supposed to be done, and it is paid for heavily by the nation; but it is not well done. I propose to improve its quality, by improving the agency to which it is assigned. I propose to substitute concentration for scattered effort, system for chance, organisation for disorder. I propose neither to exact from the Queen's advisers new duties, nor to fix upon them new responsibilities. The end and aim of my proposal is to lighten their labours and anxieties, by putting into their hands better arms than those with which they now vainly strive to uphold the power and the glory of the nation.

THE ROYAL AGRICULTURAL SOCIETY.

Wolverhampton Meeting.

The show of the Royal Agricultural Society at Wolverhampton this year was very successful, judging from the quantity of machinery exhibited, and the numbers of visitors it attracted. In fact, the element of "richness" extended not only to the exhibits and the number of visitors, but also to the ground itself. A fine piece of meadow land, which, lying somewhat low, and which had been previously abundantly irrigated with sewerage manure, however advantageous for slopping the feet of some of the four-footed visitors, acted also to a considerable extent in stopping the progress of bipeds. This drawback was, however, overcome to a great extent by the constant attention of the managers to the state of the ground, when, by judicious rolling and placing a quantity of planks over the very soft places, it was possible to walk with some appearance of comfort over almost the entire surface.

The trials for the prizes awarded for "the best combination of machinery for the cultivation of the soil by steam power," commenced at Barn-

hurst Farm, about two miles from the show-yard on the 27th of June. These were followed by trials of various cultivating machines, whether self propelling or otherwise, after which, the agricultural locomotives were put through their places. Messrs. J. and F. Howard, of Bedford, appeared in Class I. with a pair of traction engines, each furnished with two winding drums, the great novelty in their construction consisting in the boilers, which are an adaptation for portable and road purposes of the now famous, as well as successful, water-tube safety boiler. Ill-luck, however, together with want of time for thoroughly perfecting the details of these completely new forms of cngine, conspired to visit them with a chapter of minor accidents which sufficed to exclude them from trial; and of six different sets of apparatus put to work by the judges, four were entered by Messrs. John Fowler and Co., of Leeds; namely, a pair of 20-H.P. traction engines, a pair of 12-H.P. traction engines, a 12-H.P. traction engine with clip drnm and travelling anchor, and an 8-H.P. traction engine with two winding drums and travelling anchor. All the Fowler engines were self-moving along the headland, and all constructed with single cylinders and reversing gear. The implements nsed were cultivators, which are turned round at the ends of the work, excepting in the case of the clip drum set of apparatus, which worked a balance cnltivator fitted with compensating gear for holding taut the tail rope. Some of the marvels of steam cnltivation are exemplified in the following feats:—The pair of 12-horse engines with the implement and all tackle belonging to them, travelled about half a mile, passing throngh two awkward gateways, and took up position in the field ready to start in work in the short space of 15 minutes; and after completing the plot of work the whole apparatns was taken up and in readiness for the journey out of the field in only eight minutes. No help was wanted from horses, except the necessary attendance of a water-cart. The 20-H.P. set of machinery, equally manageable unless it be upon very wet land, is an illustration of the extraordinary advance made in steam tillage since the early trials of 12 or 15 years ago, when every effort was bestowed upon utilising, if possible, the thrashing engines which were already in the farmers' hands. At 100lb. pressure and 130 revolutions per minute the engines aro nominally of 20-H.P. each; bnt in work on Tuesday that pressure was greatly exceeded, the speed sometimes was fully 360 revolntions per minute, and the actnal force exerted about 120-H.P. for each engine. Driving a 9-tined cnltivator, at about 8in. depth, through a very fonl clover lea, and tearing and shattering the sandy loam soil by the pace of the implement (which was sometimes six or even seven miles per honr), the pair of engines finished a three-acred plot in 43 minutes, being at the rate of 50 acres in an autumn day of 12 hours. The Fowler pair of 12-horse engines, with a 9-tined cultivator at 8½in. depth in a clover lea, performed at the rate of 40 acres in a day of 12 hours. The single 12-H.P. engine, with a clip drnm and anchorage, driving a 7-tined cultivator 7in. deep in similar land, worked at the rate of 23 acres per day of 12 hours, and the single 8-H.P. engine, with two winding drums, anchorage, and a 5-tined cultivator, making exceedingly good work 8in. deep in the same description of soil, performed at the rate of 20 acres in a day of 12 hours.

The simplest and least expensive form of apparatns in competition consisted of the 12-H.P. double-cylinder portable engine, stationary winding windlass, and anchored pulleys on the "ronndabout" system of Mr. Smith, of Woolston, which was entered by Messrs. Barrows and Stewart, of Banbury. The rate of performance per hour and the quality of the work done did not come up to the examples already noted; but we have no data for calculating the relative total costs per acre. The other competitor in Class I. was the Ravensthorpe Engineering Company, Ravensthorpe, Mirfield, Yorkshire. If the stationary engine and windlass system is understood as the "roundabont," and the self-moving headland engine or engine and travelling anchor is known as the "direct," this may be called the "semi-direct" system, as the engine is stationary, communicating motion to two travelling headland windlasses by means of a rapidly-flying hemp or Manilla rope mounted upon light rope porters, and passing ronnd pulleys at abont 3½ft. above the ground. The speed of the cord is close upon 40 miles per hour, the winding drums npon two windlasses hauling the wire rope and implement attached at somewhat over three miles per hour. It is alleged that while the wear of the wire rope is of coursc the samo as in the case of two engines, the additional cost incurred for the hemp rope does not exceed 4d. to 6d. per acre. To work the apparatns requires four men besides porter boys; but the system involves very little labour and loss of time in removals. In fact, a whole farm may be cultivated from a portable engine stationed at a central point, where there may be a supply of water without carting, or even from a fixed engino crected inside the farm buildings; or, again, from a water-whecl or a windmill, the waste of motivc power in transmission for half a mile or moro being apparently not a very serious consideration.

In competition for the prizcs in Class II., "for the best combination of machinery for the cultivation of the soil by steam power, the weight of the steam engine not to exceed ten tons," six sets of apparatus entered into competition, of which four employed stationary engines. The Ravensthorpe Company were only 14 minutes in settling down to work; and while Messrs. Fowler's clip-drnm and travelling anchor tackle took 19 minutes in preparation, Messrs. Howard's "ronndabont" apparatns, with portable engine, occupied 21 minntes from entering the field to commencing work. In cultivating a grassy clover lea Messrs. Howard's 10-H.P. single-cylinder portable engine worked at the rate of about 16 acres in a day of 12 hours, the depth being 7½in. and the quality of the work good. Messrs. Barrows and Stewart's 12-H.P. single-cylinder portable cngine cultivated at about the same acreage per day, at greater depth, but the quality of the tillage was inferior. The apparatus of Mr. E. Hayes, of Stony Stratford, was unfortunate in performance; but the peculiar form of stationary windlass employed presents great facilities for saving time in turning at the ends, and for avoiding breakages. Upon the implement arriving at the end of the furrow the anchor man, instead of signalling, pulls a cord, which has the effect of instantly stopping and reversing the action of the winding drums, by means of a small steam-pressure break and a clever contrivance for shifting the engine-driving belt to fast and loose riggers. Two sets of machinery in competition in Class II. employed single engines self-moving along the headland—namely, Messrs. Fowler's 12-H.P. clip-drum engine and travelling anchor, working on the "direct" system, and Messrs. Howard's 10-H.P. traction engine, with two winding drums, working on what is called the "skew" plan of laying out the rope. The to and fro cnltivator made admirable work in a very foul clover lea to a depth of 8½in., and at the rate of 12 acres per day of 12 hours. A peculiarity in the construction of the engine is that the boiler is placed transversely across the frame which carries all the machinery, the drums are driven directly from the engine crank shaft, and coiling of the rope is done to perfection by means of a slow traversing sideway motion given to each drum.

To calculate the weight of earth moved per hour, or per acre, a square frame of angle iron, having an inner square frame attached to it, is laid npon the ground of which the weight is to be ascertained, and a series of blades of plate iron are driven down in the spaces abont ⅜in. wide, left between the inner and outer frames, the dimensions of these frames being such that the space enclosed by the blades when thus driven is just 3ft. square. Next the earth enclosed by the blades is cleared ont for a depth of 6in., and the weight of the earth thus removed is ascertained; and this being done the weights of two other layers, each 6in. thick, are subsequently determined. The weight of the earth in its natural state having been thns obtained, the depth of cultivation, and the weight of earth moved per acre by the cultivator may be ascertained in two ways. According to the first plan the frame is again used, the blades being driven into the cultivated ground, and the earth removed from the space enclosed by them until the untouched bottom is reached. The earth removed, is then weighed, and the weight of earth moved per superficial yard being thus ascertained, the weight per acre is readily determined, while the depth cultivated oan be readily calculated, the weight of the earth per inch in depth in its natural state being known. According to the second plan a trench is cleared in the cultivated ground, the earth being removed until the untonched bottom is reached, and the depth of cultivation is then ascertained by direct measurement, the weight of earth moved being thence obtained by calculation. At Wolverhampton both these methods were resorted to by the judges. The measurement of the fuel and water used by the ploughing engines during their runs, was carried out in the same manner as in the traction engine trials.

After the trials the judges of steam cultivating machinery—namely, Mr. Wm. Menelaus, C.E., Major H. V. Grantham, Mr. J. Hemsley, Mr. F. Sherborn, Mr. J. W. Kimber, and Mr. J. Hicken, made their awards. In Class I., "for the best combination of machinery for tho cultivation of the soil by steam power," the first prize of £100 was won by Messrs. John Fowler and Co., of the Steam Plough Works, Leeds, thc apparatus consisting of two 12-H.P. movable engines hauling to and fro a 9-tined turning cultivator, price £1,360. The second prize of £50 was also awarded to Messrs. John Fowler and Co., for their two 20-H.P. movable engincs with 13-tined turning cultivator, price £1,975. It was thns again officially declared from trial npon both light and heavy land that no system of applying steam power to tillage can eqnal in capacity of performance, the direct pulling of an implement by a single line of wire rope alternately wound and paid ont by two single-drum engines which move at intervals, and opposite to cach other, along thc two ends of the field. In Class II., "for thc best combination of machinery for the cultivation of the soil by steam power, the weight of the steam engine not to exceed 10 tons," the first prize of £50 was awarded to Mcssrs. John Fowler and Co., for their single 12-H.P. engine, movable along one headland, with self-moving disc anchor on the other, the wire rope passing round a clip drum upon the engine to a pulley npon the anchor. The implement was a double-acting balance 7-tined cultivator hauled to and fro withont

turning at the ends, and is fitted with a compensating mechanism, for holding tight the tail or return rope which is perfectly carried npon friction roller supports or "rope porters," thns economising motive power to the fullest extent. The price of the apparatus is £799. The second prize of £25 was awarded to the Ravensthorpe Engineering Company, of Ravensthorpe, Mirfield, Yorkshire, for their set of machinery on the system introduced by Messrs. Fisken. The engine—in this case a 10-H.P. traction engine—was stationary, but two single drum windlasses were employed, self-moving at intervals along the two ends of the field, and hauling the implement to and fro by a single length of wire rope. Motion is communicated to the windlasses by means of a rapidly-flying Manilla cord (or, as the exhibitors term it, "round belt"), which is led round the field monnted upon light rope-porters and pnlleys, so as to hang always clear of the ground. In the course of the trials near Stafford, the engine was stationed beside a water supply abont 200 yards away from the field cultivated, and so small a proportion of motive power was observed to be lost, and such good work was done by an apparatus which, in spite of various defects in construction, offers nnmerons advantages in working, that the judges honoured the novelty with a place in their prize list. The implement included in the set was a Fowler five-tined turning cultivator, and the price of the whole £690. In Class III. "for the best combination of machinery for the cultivation of the soil by an ordinary agricultural engine, whether self-propelling or portable, the first prize of £50 was awarded to Messrs. John Fowler and Co., for their stationary windlass tackle on the "roundabout" or hand-shifted pulley and claw-anchor system, the price, with one implement, which is a combined 4-furrow plough, digger, and cultivator, being £280, or with combined drill and two sets of harrows in addition, £375, in both cases without inclnding the engine. The second prize of £25 was awarded to Messrs. J. and F. Howard, of the Britannia Works, Bedford, for their stationary windlass tackle on the "roundabout" system; the price, with 5-tined cultivator, which was donble-acting, or hauled to and fro without being turned round, is £250, or, with a combined 4-furrow plough and digger, a set of steam harrows, and a drill with harrows, in addition, £416 10s. Lord Vernon's Cup, value £100, for the best combination of machinery for the cultivation of the soil by steam power, the cost of which shall not exceed £700, the engine to be locomotive and adapted for thrashing and other farm purposes," was awarded to Messrs. John Fowler and Co., the machinery consisting of a single 8-H.P. movable engine with two winding drnms, working a wire rope in connection with a self-moving disc-anchor pnlley at the other end of the field which, for the rope supplied, may be 600 yards long; the price, with combined 4-furrow plough, digger, and cultivator, being £698. The prize of £20 for the best windlass was awarded to Messrs. Tnxford and Sons, of Skirbeck Ironworks, Boston, Lincolnshire, for their stationary two-drum windlass with expanding friction couplings and automatic friction brakes. The prize of £10 for the best snatch-block, or snbstitute therefor, was awarded to Messrs. Amies, Barford, and Co., of Peterborongh, for their "Campain's patent" self-moving disc-anchor. Messrs. John Fowler and Co., took the prize of £25 for the best plough for steam power, the prize of £20 for the best snbsoiler, the prize of £25 for the best digger, the prize of £25 for the best cultivator, and the prize of £20 for the best skim plough or scarifier. The prize of £10 was awarded to Messrs. Amies, Barford and Co,, for the best steerage steam roller. The prize of £10 was awarded to Messrs. J. and F. Howard, for the best steam harrows. The prize of £20 for the best steam drill was equally divided between Messrs. J. and F. Howard, and Mr. James Coultas, of Grantham, Lincolnshire. The prize of £10 was awarded to Messrs. John Fowler and Co., for their set of patent root and stone eradicating machinery.

The trials "for the best agricultural locomotive engine applicable to to the ordinary requirements of farming" were somewhat disappointing as several engines entered in the lists did not put in an appearance owing to the extraordinary state of the ground. As, however, it must be presumed, that an engine to be of any use for farm purposes, mnst be able to do its work in all states of the weather, the late trial was eminently calculated to test their real utility. In consequence of the heavy rain which fell without intermission the whole day and night previons to the trials, several of the competitive engines were withdrawn, only four coming up to the scratch.

The first and crack performance of the day was accomplished by the 6-H.P. traction engine of Messrs. Aveling and Porter, of Rochester. This engine, weighing 5 tons $4\frac{1}{2}$ cwt., with coal and water, and dragging a four-wheeled truck loaded with pig iron to a total gross weight of 5 tons 10 cwt., ran round the course in 52 minutes, with a consumption of 153lb. of coal. Armed with spud-blades and spikes, the 10in. broad wheels were able to lay hold of the wet ground, and to travel without "skidding" or slipping; these aids being temporarily removed during the short portion of the journey which was upon a common highway road. The method of driving both main wheels simultaneously, and with equal force no matter what may be the difference in their relative speeds, enables the engine to exert her full gripping power upon the soil whether proceeding in a direct line or round a curve; and the steering is effected with remarkable ease and facility. This may be appreciated when we say that, instead of employing one man to drive and another to steer, Mr. Aveling intrusted the whole management of the engine during the race to a lad named William Illman, who at Leicester in 1868 (when he was only 13 years of age), won the admiration of everybody by the skill, nerve, and jndgment with which he careered the "Little Tom" engine through all parts of the crowded showyard.

Just after Messrs. Aveling and Porter's engine completed their run, a start was made by Messrs. Ransomes, Sims, and Head's engine, steered by Mr. John Head, and taking a load of 5 tons behind it. On the rise between the 5th and 10th chain posts, however, Messrs. Ransome's engine came to a stand, but a start was made again, and in about 11 min. the 18th chain post was reached. Here the course passed through a gateway where there had been much traffic, and notwithstanding the alleged suitability of india-rubber tyres for soft ground, the engine stuck. After a stop of $17\frac{1}{2}$ min., and the application of planks, ashes, and much digging, another start was made, and the engine got on well until a stop was made in the public road near the 105th chain post to take in more water. This being accomplished, the engine made the turn into the gateway, and commenced the task of ascending the sides of the hollow already referred to in speaking of Messrs Aveling and Porter's trip. Here, however, the india-rubber tyres proved ntterly useless. They slipped on the ground and the wheel slipped inside them, and notwithstanding the laying down of planks, and mnch digging and hard work generally, it was 22 min. before the engine without its load had reached the top of the bank.

Jnst after this a regular thunderstorm came on, and the heavy rain soon made the ground worse than ever. The softer the ground became the less the india-rubber tyres seemed to like it, and although Mr. Head, by sticking manfully to his task, managed at last to get his wagon up the bank, yet he then found himself compelled to abandon it, and take his engine home without its load. Even this, however, was not done without numerous stops, the engine having to be regularly dug out several times, and it was not until 4 hours 10 min. after starting that it eventually completed its trip.

The state of the ground after these exploits, and the continned rain, may be imagined, but it can scarcely be adeqnately decribed. Mr. Burrell, after witnessing Messrs, Ransome's trip, sensibly withdrew his india-rubber tyre engine from competition, while Messrs. Amies and Barford also withdrew the engine made by Messrs. Tuxford. Thus there only remained Messrs. Aveling and Porter's 10-horse engine, and with this Mr. Aveling determined to make a run notwithstanding all circumstances. At first a load of 10 tons was applied, bnt this was reduced to 9 tons, and with this load a fair start was made. Shortly after starting a tooth, and subsequently another broke out of one of the wheels of the compensating gear, but these mishaps caused no failure, and with some brief stops for applying and removing spikes, the engine made the run with complete success in 65 minutes. This last performance was certainly very wonderful, as in some parts the wheels were np to their axles in mud, and the waggons had to be drawn throngh the mud with their wheels standing still.

The show-yard was opened to the public on the 10th ult., when in consequence of the finer weather than had been previously experienced at the trials, there was an unusually large attendance of visitors. As usnal in these exhibitions, it was somewhat difficult to discover any novelty, that was also a valuable improvement over what has already been done. There were, however, a few, amongst which may be mentioned a curious description of plough, which in this instance, was entered as a machine for cultivating hop gardens. It was exhibited by Messrs. Mellard's, Trent Foundry Company (Limited), and is designed to snpersede manual labour. It consists of a plongh with a rotating disc mould-board. On the light land at Barnhurst and also in the heavy land fields near Stafford, this novel implement has astonished the jndges by the completeness of the tillage which it accomplishes at a single operation, with a proportionately small expenditure of power. Cutting a furrow 12in. wide and 10in. deep, the "revolver" perfectly buries the sward or stubble, and crumbles and spreads the upturned soil after the manner of the most garden-like spade-work, at the same time tossing out root-weeds. For making a seed-bed at one stroke, provided the land be in suitable order, nothing can surpass this implement. Apparently, the draught is by no means heavy, considering the result which is obtained in the pulverisation of the furrow-slice. There was also a very neat double plough exhibited by Mr. Underhill, of Newport, which, by the judicious arrangement of the framing, was very light and strong. The framing was also fitted with eyes, into which tines could be fitted so as to convert it into a grubber. These double plonghs have another advantage over the ordinary combined plough, viz., that they enable the horses to walk in the furrows. A portable engine was also exhibited by the same maker

with a compound slide-valve actuated by the governor, of which we hope shortly to give an engraving.

We may also mention a very simple and ingenious brickmaking machine by Mr. J. D. Pinfold, Warwickshire Works, Rugby, where the cutter is placed at such an angle to the table, that it cuts square bricks without arresting the motion of the clay. As, however, this action is not easily described without an illustration, we must reserve it for a future number.

There was many other exhibits well worthy of notice, but which, from want of space, we must defer until our next issue. Amongst these, may be mentioned the magnificent show of Messrs. Ransome's, of Chelsea, who amongst other things astonished the public by manufacturing by machinery from a tough piece of wood, the peculiar shaped handle used for adzes and hatchets. Messrs. Powis, James and Co., had also a very fine display, amongst which may be mentioned a diagonal engine attached to an upright boiler, which appeared to be a very nice arrangement. Although scarcely a department of engineering, we could not help admiring the rustic houses made by Mr. H. Inman, of Manchester, which were very perfect specimens of that species of manufacture.

(To be continued.)

ALEXANDRIA HARBOUR WORKS.

On the 15th of May, the first stone was laid of the new port of Alexandria. A plan for providing Alexandria with a large and commodious harbour and docks was under the consideration of the Egyptian Government some time ago, and a concession given to a French company, which fell through, however, owing to the failure of this company, the scheme was then taken up by Messrs. Greenfield, Elliot, M.P., Maclean, M.P., Kennard, and Abernethy, and after three years' delay and many modifications in the original plan a contract was signed last year between the Egyptian Government and these gentlemen, under the title of Greenfield and Co., by which they undertook for a sum of £1,800,000 to finish in six years' time works which will give Alexandria one of the largest and most convenient harbours in the world.

The first item in the programme of the new harbour works is the construction of a breakwater. This breakwater is to begin about 600 yards from Ras el Teen Point, the intervening space being left for the passage of small coasting vessels, which can pick their way through the reefs and proceed in a westerly direction to a rock called Aboo Beker. From this rock it will turn almost due south, and continue up to the edge of the entrance channel, about a mile distant from the Central Pass. The length of the breakwater will be about a mile and a half. It will be constructed of massive concrete blocks, thrown irregularly into the sea, but the inside face will be composed of blocks of natural stone, with rubble to fill up the interstices. When this breakwater is completed there will be 3,000 acres of still water completely sheltered from the surf. The next work is the running out of a mole from the west side of the Mahmoodieh Canal. This mole will be three-quarters of a mile long, and over 60ft. wide. The outer side will be composed of concrete blocks similiar to those used for the breakwater, and the inner built of stone, so that the mole may serve as a landing quay 300 yards long, and from the east side of the canal another quay will run along the head of the bay, where the present landing places are, as far as the Arsenal, a distance of about three-quarters of a mile.

REVIEWS AND NOTICES OF NEW BOOKS.

We have received the following:—"Power in Motion," by James Armour, C.E. (London: Lockwood and Co.); "Light-house Illumination," by Thomas Stevenson, C.E. (Edinburgh: A. and C. Black); "Iron Bridges and Girders, &c.," by F. Campin, C.E. (London: Lockwood and Co.); and "Mechanical Puddling," by George Ryland (Birmingham), which owing to want of space stand over until next issue for review.

NOTES AND NOVELTIES.

MISCELLANEOUS.

The Taunton Board of Health has resolved to purchase for £700 a field for the purpose of utilising the sewage of the town.

The Steel Works at Gorton, which are situate near Manchester, and which were recently purchased by Messrs. Bolckow, Vaughan, and Co., the great iron-makers, Middlesbrough, have been altered and started as Bessemer steel works.

A short time ago Messrs. Robey and Co., of Lincoln, made an experimental trip with their road steamer on Thomson's principle between Grantham and Lincoln. The load consisted of two immense omnibuses built by Mr. Boyd of Grantham, and the steamer is reported to have overcome all the difficulties of the road and the weight with remarkable success.

The Peruvian Government having been authorised by virtue of a law of January 23rd, 1871, to invest £2,000,000 in works for irrigation purposes, has advertised for tenders with a view to the irrigation of the Valley of Azapa in the Department of Moquegua.

A new washing machine, the invention of Mr. Ralph Stewart, nephew of the proprietor, Bailie Walker, has recently been introduced to the works at Elgin Bleachfield, Dunfermline. The machine, which we understand has been patented, seems to combine the various advantages which never fail to render an invention acceptable to practical men. It does its work thoroughly, washing and cleaning the yarn in a manner much more satisfactory than the former arrangements secured. It economises labour, and at the same time expedites the operations of the works, accomplishing with a comparatively limited staff of bleachers considerably more work than could be overtaken by the much larger staff employed under the method it has superseded. And it possesses the additional recommendations of being simple in structure, easy of management, and conductive to the comfort of the operatives. Compared with the machine formerly in use, its excelling feature is an ingenious contrivance by which the yarn is kept in motion and shaken while passing through the pond. The invention has been inspected by most of the employers in the neighbourhood, and several have already made arrangements for its introduction into their works.

Professor Agassiz having had a coast survey steamer placed under his control is examining the waters of the Pacific on the North American coast, and in connection with deep sea soundings he will collect specimens of natural history.

The committee of the Society of Arts appointed to examine the relations between Government and inventors have come to the conclusion that reasonable grounds exist for dissatisfaction as to the treatment which the latter have received. The committee have examined many witnesses, and they passed a resolution to the effect that "the present system of dealing with inventors is unmethodical and unsatisfactory, and the one obvious defect of the present system is the want of a suitable record of the invention submitted, and of the proceedings taken therein." The committee think that a report upon each invention should be presented by suitable persons, independent of the public department using it and of the inventor.—*Globe.*

Whether public-houses should be closed for a greater number of hours every day in the week is a disputed question, but there seems to be a general agreement that it would be a boon to the families of working men, if the publics were closed an hour or two earlier on Saturday nights. Less of the wages would be squandered, and the wives would get the money in time for their marketing instead of having to buy the Sunday dinner on Sunday morning.—*Food Journal.*

The second artesian well sunk with a view to determine the thickness of the sulphur beds of Louisiana and the nature of the superincumbent strata has reached a depth of 522ft. At a depth of 428ft. it struck the sulphur-bearing stratum. This was 112ft. in thickness, made up of layers of pure crystalline sulphur, alternating with white limestone mixed with sulphur. These were surmounted by 41ft. of white crystalline limestone, and underlaid by 12ft. of limestone containing some white sulphur. Professor Hilgard advances the opinion that these deposits had their origin in reactions between gypsum and lignite, the former being in excess.

The weight of the seed produced (says the *New York Times*) in the Southern States is estimated at 2,000,000 tons, being about double that of the cotton from which it is gained; but it is supposed that, after deducting the quantity necessary for planting, waste, &c., there will remain about 1,000,000 tons, valued at 12,000,000 dols. The value of the hulls for fertilising purposes is estimated at 20 dols. per ton, and it is also estimated that the seed crop all might be made to yield a total value of over 40,000,000 dols., over and above the quantity reserved for seeding. If the whole seed product could be saved and sold at its marketable value, it would be sufficient to meet the provision cost of cultivating a crop of cotton. A man and a mule will produce ten bales of cotton, weighing 4,500. This will afford 9,000 lbs. weight of seed, which will bring 64 dols. in the market. The cereal food of the man and mule will cost 63 dols.; the seed of cotton may, therefore, be made to pay more than three-fourths of the corn consumed. Within the last two or three years the trade in these products has assumed large proportions. At first, no one knew to what purposes the oil was put, but it has come gradually to be understood that it mixes well with other and more costly oils. Not long since, it was discovered that some of the well-known brands of olive oil imported from France had been counterfeited, and cotton-seed was supposed to be at the bottom of it. Most of the seed is crushed in the forest, so that it is not known what proportion of the oil produced is consumed there. Some of the stearine made in the process of pressing is as sweet and yellow as butter. The cake made in pressing is shipped to England and fetches about £2 per ton.

TELEGRAPHIC ENGINEERING.

The Chilian Government has resolved to proceed with the construction of three additional lines of telegraph. These lines will extend from Nacimiento to Los Angelos, Quiribue to Cauquenues, and Petorca to the main northern line.

A privilege for forty years has been granted to Messrs. Lamas for laying a submarine cable between Rio and Buenos Ayres. Buenos Ayres is now in electric communication with the remotest provinces of the Argentine Confederation; by the end of this year the Argentine Republic will probably be also enjoying telegraphic intercourse with Chili and the Pacific coast. The Banda Oriental Government has granted a concession of a line between Monte Video and Yaguakou in Rio Grande. The works of the Transandine telegraph have been commenced on the Chilian side of the Andes and are being pushed forward vigorously.

STEAMSHIPPING.

One of the quickest passages ever made between New York and Liverpool has just been accomplished by the Inman Company's steamer *City of Brussels*, under the command of Captain Kennedy. She left the first-named port about 11 o'clock on the morning of the 8th ult., and arrived off the bar at Liverpool at 4 o'clock on the afternoon of the 17th, the voyage having thus been completed in a little over nine days.

A line of steamers is said to be in contemplation between New Orleans and Central and South American ports. The object of the enterprise is to secure the coffee trade.

The *Agincourt* is now in the dry dock at Plymouth; she is not materially damaged, and it is said some £3,000 expended upon her will make her as strong as ever. On the port side, one hundred feet from her stern, the vessel's massive iron bilge keel is torn away for fifteen feet, and her outer bottom ¾in. plates indented for ten feet, the extreme indentation being five inches. On the other side of the vessel, one hundred feet from the bow, the bilge keel for twenty-three feet is bent outwards, and for the same distance the plates are slightly bulged in close to the keel, which is bent inwards five inches. The manholes in the bulk-heads, which ought to have been water tight, proved not to be so; consequently, when the *Agincourt* struck, the water filled her double bottom, and even got into the bread-room and under the stoke-holes.

SHIPBUILDING.

It is expected that great increase in the German fleet will be made during the next few years. In addition to three turret vessels, of which two are to be built at the dockyard at Kiel, and one by the Vulcan Company at Stettin, seven corvettes are to be constructed at Dantzic, and are to be all finished by 1877.

Messrs. Thos. Wingate and Co., Partick, have contracted for another large screw steamer, of about 2,500 tons, for Messrs. Lewis T. Merrow and Co.'s Transatlantic Line. These steamers are to be classed A 100 at Lloyd's, and for speed, carrying capacity, and passenger accommodation, are intended to compete with the best afloat.

Messrs. Caird and Co. have been commissioned to build another steamer for the Hamburg American Company, of 2,774 tons and 600 h.p. engines.

LAUNCHES.

There was lately launched from the shipbuilding yard of Messrs. J. and R. Swan, Maryhill, a handsome screw steamer of 100 tons burthen, designed for the coasting trade. She is the property of Mr. James Sinclair, Stirling, and was by his son William, named the *Sterling of Sterling*.

There was launched successfully on the 24th June by Messrs. Charles Connell and Co., from their new shipbuilding yard at Scotstoun Whiteinch, near Glasgow, a finely modelled screw steamer of 1,000 tons, built in accordance with Lloyd's new rules. She was gracefully named *Governeur-Generaal Mijier* by the lady of Capt. Lindemann, who is to have the command of the steamer. The vessel has been built to the order of the Netherlands India Steam Navigation Company (Limited), for their line of mail steamers in the Dutch colonies.

There was launched at Dumbarton by Wm. Denny and Bros. on the 24th June a screw-steamer of 1,780 tons register, intended as the first of a line of steamships being established from Clyde to Rangoon by Messrs. P. Henderson and Co., of Glasgow, and for which the same builders have now in course of construction other three vessels. The *Tenasserim*, named by Master Charles Edward Galbraith, will be fitted by Messrs. Denny and Co. with machinery on compound principle, and will sail from Glasgow on the 10th inst., and, being coaled for the entire voyage, is expected to make the passage in 38 days.

A handsome new spar-decked screw steamer of 1,400 tons, built and engined by Messrs. Wm. Simons and Co., was on the 4th June launched from the London Works, Renfrew. It is named *Baghdad*, and is classed the highest grade at Lloyd's. She is fitted with compound engines, steel propeller, teak decks, and very elegant cabin accommodation. This fine steamer is the property of Messrs. Gray, Dawes, and Co., London, and is the second steamer constructed for them by this firm.

A splendid screw steamer, of about 2,000 tons, was launched from the building yard of Messrs. R. Duncan and Co., Port-Glasgow, for the Anchor Line Company, Messrs. Handyside and Henderson, Glasgow, on the 18th ult. Her dimensions are:—Length, 270ft.; depth 30; breath, 35. She is named the *Trinacria*, and is intended as an addition to that section of the Anchor Line fleet which sails from the Clyde to the Mediterranean, and thence to New York and home. Her fittings are in first-class style, and include many of the latest improvements, notably a patent for facilitating the steering of the ship.

TRIAL TRIPS.

The steamer *Gala*, 183 tons gross register, built for the Berwick and London Steam Shipping Company (Limited), lately left Greenock on trial with a number of the directors on board. After steaming round the Island of Bute, the vessel's speed was tested at the measured mile, and found to be 11½ miles per hour, which was considered highly satisfactory. The engines were supplied by Messrs. Rankine and Blackmore, Greenock, and indicated over 400 H.P.

RAILWAYS.

The works of the Great Northern Railway of the province of Canterbury (New Zealand) are progressing towards Kaiapoi. The fencing is complete to the Styz, and the provincial government has invited tenders for the erection of an iron girder bridge over the north branch of the Waimakariri.

The joint committee of the Great Western and Midland Railway companies Clifton Extension have resolved to proceed without further delay with the construction of this branch railway. The line is about three and a-quarter miles in length, and will bring this fashionable suburb of Bristol into direct communication with those railways, and with the Channel docks now in course of construction at Avonmouth.

The London, Chatham, and Dover Railway Company are immediately about to commence the construction of an important short junction railway which will confer a very considerable advantage on the public and excursionists going to the Crystal Palace, *via* Ludgate-hill. The new junction line, which is little more than a mile in length, but which will effect a saving of upwards of two miles between Ludgate-hill and the Crystal Palace, will thus materially reduce the distance by avoiding the roundabout angle at Brixton, and enable passengers to go direct from Ludgate-hill to the Palace without changing carriages. It will also form a direct link of communication to the Palace between the north and south of the metropolis, and in the case of excursionists from the north by the Midland, Great Northern, and other companies, to enable those companies to bring their passengers direct to the Palace without change of carriage.

TRAMWAYS.

Wire tramways are beginning to be adopted at the iron ore mines of the Forest of Dean and Somersetshire for the conveyance of ore to the local railways. These tramways seem destined to exert a rather important influence on local industry.

A prospectus has been issued of the Edinburgh Tramways Company, with a capital of £30,000, in shares of £10. The company has been incorporated by a special Act of Parliament to carry out a system of street tramways in Edinburgh and its suburbs, especially in Leith and Portobello. The length comprised will be about eighteen miles of double line.

A line of tramway between Azap Capou and Beschitash will shortly be opened for traffic. The cars which will be run are from the workshops of a well-known Vienna builder. A Stamboul line from the Yeni Dami mosque to Ak-Serai has been nearly completed.

ACCIDENTS.

On the night of the 3rd ult. a passenger train running westward from Nashville to Hickman, a town on the Mississippi River, while at a comparatively slow speed, broke through a weak bridge and fell a wreck into the Harpeth river, a stream 18 miles from Nashville. This railway is described as very poorly constructed, and the bridge even before the disaster was believed unsafe. Fifteen persons were killed and 23 injured, the greater portion of the train having been thoroughly broken to pieces.

Another bridge on the Madras Railway has given way. In this case the structure which has failed is on the Bellary branch of the company's system, and it is familiarly known in the Presidency as the Veerapoor bridge. The goods traffic on the branch is suspended for the present, while the usual shifts are resorted to in connection with the passenger traffic.

DOCKS, HARBOURS, BRIDGES.

The Detroit River Tunnel Company has been organised, and Mr. J. F. Joy has been elected president. The works are expected to be soon commenced and trains will probably be passing through the tunnel within two years.

Locomotives have now passed over a great iron railroad bridge over the Ohio, at Benwood, which has been in course of construction for two years. The bridge is nearly three-fourths of a mile in length. The channel span is 350ft. wide and 95ft. above low-water mark, while it contains 600 tons of iron. The approach on the Ohio side is by an arcade of 41 arches, which is considered a very fine piece of masonry. The arches of the arcade are 40ft from centre to centre.

The first stone of the Tay Bridge on the Fife Shore was laid on the 22nd ult. without any ceremony. A considerable number of the caissons for the piers have already been cast, and some idea of the magnitude of the work may be formed when we state that there will be not less than 35,000 tons of iron in the bridge, and 35,000 tons of bricks, irrespective of the stone.

LATEST PRICES IN THE LONDON METAL MARKET.

	From			To		
COPPER.	£	s.	d.	£	s.	d.
Best selected, per ton	77	0	0	78	0	0
Tough cake and tile do.	76	0	0	,,	,,	,,
Sheathing and sheets do.	78	0	0	80	0	0
Bolts do.	79	0	0	80	0	0
Bottoms do.	82	0	0	83	0	0
Old do.	60	0	0	,,	,,	,,
Burra Burra do.	76	0	0	77	0	0
Wire, per lb.	0	0	9¾	0	0	10
Tubes do.	0	0	10½	0	0	10¾
BRASS.						
Sheets, per lb.	0	0	8	0	0	9
Wire do.	0	0	7¾	,,	,,	,,
Tubes do.	0	0	8	0	0	10½
Yellow metal sheathing do.	0	0	7	0	0	7½
Sheets do.	0	0	6¾	0	0	6⅞
SPELTER.						
Foreign on the spot, per ton.	18	5	0	18	10	0
Do. to arrive.	18	5	0	,,	,,	,,
ZINC.						
In sheets, per ton	24	10	0	,,	,	,,
TIN.						
English blocks, per ton.	137	0	0	138	0	0
Do. bars (in barrels) do.	138	0	0	139	0	0
Do. refined do.	139	0	0	140	0	0
Banca do.	135	0	0	,,	,,	,,
Straits do.	134	0	0	134	10	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	9	6	1	10	6
IX. do. 1st quality do.	1	16	0	1	17	6
IC. do. 2nd quality do.	1	7	6	1	8	0
IX. do. 2nd quality do.	1	13	6	1	14	0
IC. Coke do.	1	6	0	1	7	0
IX. do. do.	1	12	0	1	13	0
Canada plates, per ton	13	10	0	15	0	0
Do. at works do.	13	10	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	12	6	,,	,,	,,
Do. to arrive do.	7	10	0	,,	,,	,,
Nail rods do.	7	10	0	7	15	0
Do. Stafford in London do.	7	12	6	8	0	0
Bars do. do.	8	0	0	9	2	6
Hoops do. do.	8	2	6	8	5	0
Bars do. at works do.	7	15	0	8	0	0
Hoops do. do.	9	0	0	,,	,,	,,
Sheets, single, do.	9	7	6	11	0	0
Pig No. 1 in Wales do.	3	15	0	4	5	0
Refined metal do.	4	0	0	5	0	6
Bars, common, do.	6	15	0	7	0	0
Do. mrch. Tyne or Tees do.	7	5	0	,,	,,	,,
Do. railway, in Wales, do.	7	0	0	,,	,,	,,
Do. Swedish in London do.	9	17	6	10	0	0
To arrive do.	9	15	0	9	17	6
Pig No. 1 in Clyde do.	2	19	0	3	6	0
Do. f.o.b. Tyne or Tees do.	2	6	6			
Do. Nos. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	0	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	16	0	0
English spring do.	17	0	0	23	0	0
Quicksilver, per bottle	9	10	0	,,	,,	
LEAD.*						
English pig, common, per ton	18	0	0	18	2	6
Ditto L.B. do.	18	2	6	18	5	0
Do. W.B. do.	19	5	0	,,	,,	,,
Do. sheet, do.	18	10	0	,,	,,	,,
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	20	10	0	,,	,,	,,
Spanish do.	17	12	6	17	15	0

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

DATED JUNE 10th, 1871.

1537 J. Davey—Plough
1538 R. D. McKellen—Winding thread
1539 R. Olpherts—Presses
1540 J. L. Adam—Inkstands
1541 H. Howse—Sewing machines
1542 J. Keats—Sewing thread
1543 J. P. Allen—Indicating speed
1544 W. Tavener—Lowering and raising window sashes
1545 J. R. and F. C. Tussaud—Separating hair, &c.
1546 T. Cowhurn—Preventing the explosion of steam generators
1547 J. Moody—Keels for ships
1548 R. H. Eddy—Bretelles

DATED JUNE 12th, 1871.

1549 G. Wright—Billiard tables
1550 S. Janicki—Floating docks
1551 A. de Bergue—Supplying water to steam boilers
1552 R. Long—Increasing the circulation of water in steam boilers
1553 S. Russell—Perspective drawings
1554 A. Lyle—Dressing wood
1555 J. F. Allan and J. Moffat—Gas holders
1556—S., J., and R. Turner—Packing
1557 F. Benuett—Tiles
1558 W. E. Gedge—Lime kilns

DATED JUNE 13th, 1871.

1559 J. Hunter—Furnaces
1560 F. Barford—Straw plait, &c.
1561 L. Wright—Potato drills
1562 R. Barrett and S. Wright—Hand-stamping machines
1563 W. E. Simmonds—Governor
1564 J. Boynton—Pen wipers
1565 A. Kent—Gas retorts
1566 L. Chapman—Gang plough

DATED JUNE 14th, 1871.

1567 G. Barker and J. McFarlane—Rails
1568 J. Jarvis, J. Rohb, and A. Masson—Straining pulp
1569 P. H. Samuels—Spring mattress
1570 W. L. Lihhey—Glass blowers' mould
1571 W. Walker—Preventing accidents in mines, &c.
1572 W. Richards—Firearms
1573 C. Parkinson—Frictional apparatus
1574 Capt. A. Hamilton and J. Sax—Signalling apparatus
1575 F. H. Trevithick—Excavating land
1576 J. and W. Evans—Pumping machinery
1577 J. J. Franks—Iron rails, &c.
1578 J. H. Johnson—Ships, &c.
1579 G. E. Marchisio—Olive oil

DATED JUNE 15th 1871.

1580 T. J. Searle—Bedsteads
1581 A. Waddington and W. J. Turner—Singeing textile fabrics
1582 T. Howcroft and A. McGregor—Reaping machines
1583 J. Pearson—Dressing goods
1584 H. Briggs—Removing sunken vessels
1585 W. H. Clubbe—Artificial flowers
1586 R. Olpherts—Presses
1587 R. Russell—Drying apparatus
1588 E. Pilgrim and A. Eli—Stopping hot-tles, &c.
1589 J. B. Spence and P. Dunn—Treatment of alumina
1590 J. Pearson—Dressing goods, &c.

DATED JUNE 16th, 1871.

1591 J. Gray—Ploughs
1592 J. F. W. Templeton—Putting names upon cork, &c.
1593 G. Ermen—Polishing yarn
1594 A. Z. Houbé, A. Guinet, and V. E. Lemarchand—Cutting wood, &c.
1595 T. Fawcett—Sawing timber
1596 M. Stell—Spinning worsted, &c.
1597 R. B. Lee and S. A. Rogers—Metal pillars, &c.
1598 G. Clifford—Crucihles
1599 D. Greig and W. Daniel—Compressing air
1600 A. M. Clark—Looms

DATED JUNE 17th, 1871.

1601 J. Saxby—Locking apparatus
1602 P. P. de Grandchamp—Improvements in Jacquard's looms, &c.
1603 J. Page—Tramways
1604 S. Tetley and W. Smith—Preventing waste, &c.
1605 T. Craig—Sweeping streets
1606 W. R. Watson—Crushing sugar cane

DATED JUNE 19th, 1871.

1607 W. McNahh—Cutting bands
1608 J. B. Robertson—Sewing machines
1609 W. Poupard and J. Thomson—Increasing the updraught in chimneys
1610 D. Parrish—Towelling
1611 A. C. Moffatt—Door springs

DATED JUNE 20th, 1871.

1612 E. A. Cowper—Driving drifts
1613 P. Frankenstein and S. Phillips—Fastenings of leggings
1614 T. R. H. Fisken—Imparting motion to rollers, &c.
1615 J. Mullin—Mules for spinning
1616 E. R. Handcock—Propelling vessels
1617 E. Jones—Cartridge cases
1618 C. Breitenbach—Scouring flours
1619 J. Duncan—Sugar
1620 S. Moorhouse—Steam boilers
1621 G. A. F. Fowke—Standards used in wire fencing
1622 M. Leon Somzé—Joints for pipes
1623 J. Foster—Grinding the teeth of cards for carding flax
1624 A. Guattari—Telegraph apparatus

DATED JUNE 21st, 1871.

1625 C. G. Wilson—Pressing cotton
1626 J. Unwin—Depositing nickel on silver
1627 St. John V. Day—Rolling stock
1628 G. B. Galloway—Homogeneous metal
1629 F. A. and T. Whitham—Winding frames
1630 H. S. Coleman and A. G. E. Morton—Cultivation of land, &c.
1631 B. S. Cohen—Pencils
1632 W. Walcker—Transmitting sounds
1633 I. Liebich and W. W. Paterson—Pianofortes
1634 W. E. Gedge—Permanent way
1635 C. W. Harrison—Application of electricity to therapeutic purposes

DATED JUNE 22nd, 1871.

1636 W. Butterworth and J. Haworth—Consuming smoke
1637 J. M. Macintosh—Seed sower, &c.
1638 D. Sproul—Refrigerating the heads of invalids
1639 W. R. Lake—Treadle mechanism
1640 E. T. Hughes—Castors
1641 E. T. Hughes—Regulating the supply of water, &c.
1642 E. König and J. Henderson—Obtaining sulphate of soda
1643 H. Highton—Galvanic batteries
1644 J. C. Macdonald and J. Calverley—Printing and cutting into sheets rolls of paper
1645 W. E. Gedge—Comfits
1646 J. H. Johnson—Spark arresters
1647 W. R. Lake—Firearms

DATED JUNE 23rd, 1871.

1648 G. White—Designs on metal plates
1649 F. Taylor—Spring mattresses
1650 F. W. Colls, H. Atkinson, J. J. Michael, and T. W. Knight—Preparing pulp
1651 R. Moubray—Treating maize
1652 J. R. Ord and H. Maddison—Breaking stones
1653 W. R. Lake—Disentegrating machine
1654 C. Crossman and J. H. Ferguson—Horseshoes
1655 J. Saxby—Locking apparatus
1656 J. B. Payne and W. E. Newton—Twines, &c.

DATED JUNE 24th, 1871.

1657 W. A. Lyttle—Signalling apparatus
1658 M. Benson—Organs
1659 B. Hunt—Steam engines
1660 T. Lawes—Agricultural implement
1661 J. Peacock—Printing patterns on cloth
1662 W. Hardinge—Cartridge pouches
1663 J. Storer—Wheelbarrows
1664 H. Libbey—Glass blowers' moulds
1665 H. Lefevre—Effecting calculations
1666 G. Sinclair—Treating spent ley
1667 T. Webb—Creel frames

DATED JUNE 26th, 1871.

1668 E. Bazin—Spinning machines
1669 W. Bentley—Administering medicine to horses
1670 H. Bottomley—Treatment of yarn
1671 W. Burns—Pipe joints
1672 A. Giles—Agricultural implement
1673 A. Giles—Turning grass
1674 G. Glover—Bedsteads
1675 G. Gwynne—Treating fatty hodies
1676 A. M. Clark—Rail or tramway

DATED JUNE 27th, 1871.

1677 P. W. Parkin—Harness-tug stops
1678 W. Campbell—Lowering lifeboats
1679 T. W. Parker and J. Greenwood—Mules for spinning
1680 J. Davis, A. Ilbery, B. Isangk, and J. Sullivan—Recording graphically the pressure of steam, &c.
1681 J. W. Melling—Engines
1682 H. Deacon—Chlorine
1683 J. Crofts, R. Dawson, and J. King—Combing wool
1684 H. D. Rawlings—Filling hottles
1685 J. J. Perry—Letters, &c.
1686 B. J. B. Mills—Battery guns

DATED JUNE 28th, 1871.

1687 A. Metcalf and W. Gibbons—Faller reliever
1688 F. Rath—Plaited fabrics
1689 R. Shephard—Looms
1690 P. Jensen—Roofing
1691 W. Scott—Guns
1692 H. Large—Making bricks
1693 Sir J. Bethune—Traction engines
1694 W. Mackinder and G. Johnson—Ploughing

DATED JUNE 29th, 1871.

1695 M. Pinder—Joints for pipes
1696 B. Sawdon—Sewing machines
1697 J. S. Starnes—Filtering water
1698 J. R. Greaves—Night lights
1699 S. Corbett—Ploughs
1700 B. E. R. Newlands—Manures

DATED JUNE 30th, 1871.

1701 J. Lidderd—Railway chairs
1702 A. J. Deblon—Calendering stuffs
1703 E. Quinn—Double cranks
1704 T. T. Macneill—Cigarettes
1705 J. M. Napier—Weighing machines
1706 J. Birch—Steel
1707 T. Baker—Umbrellas
1708 W. R. Lake—Ripping instrument

DATED JULY 1st, 1871.

1709 R. Long—Bridges for furnaces
1710 A. Lilley—Lubricators
1711 T. Reid—Ploughs
1712 J. Lewis—Bedsteads
1713 W. R. Lake—Valves of water meters
1714 G. C. Chipman—Envelope
1715 W. R. Lake—Luhricating compound

DATED JULY 3rd, 1871.

1716 P. J. Davies—Prevention of damage caused by the hursting of water pipes
1717 R. Long—Paddle wheels
1718 G. C. Wilson—Cartridge cases
1719 J. Jordan—Furnaces
1720 A. Nussey, A. Pilling, and C. H. Hall—Sewing machines
1721 J. Jervis—Cutlery
1722 S. Mason—Lined vacuum kiers
1723 W. E. Gedge—Composition for destroying the larvæ of may hugs
1724 E. N. Schmitz—Gas engines
1725 T. J. Smith—Recovery of potash, &c.
1726 T. J. Smith—Reaping machines
1727 A. M. Clark—Coffee pot
1728 W. J. Schlesinger—Whisk for eggs
1729 W. J. Schlesinger—Clip for bills
1730 J. Smart—Packing stuffing boxes

DATED JULY 4th, 1871.

1731 J. Rawcliffe, jun., W. Bibby, and A. Fleming—Mules for spinning
1732 E. T. Hughes—Spring hed bottoms
1733 J. Hargreaves and T. Robinson—Manufacture of sulphates
1734 J. Dickson—Harrows
1735 W. T. Walker—Cleansing gas
1736 G. F. Griffin—Motive power
1737 H. Bessemer—Asphalte pavement
1738 J. Charles and C. Taylor—Floor cloth
1739 W. J. Schlesinger—Soap dish holder
1740 J. Ramsbotton—Hydraulic engine
1741 A. S. Dixon—Gauge cock
1742 J. A. Hogg—Safety lamps
1743 W. E. Newton—Roads, &c.
1744 J. Willcox—Sewing machines
1745 J. Hildred—Ventilating sewers
1746 J. Robertson—Finishing textile fabrics
1747 N. F. Taylor—Lamps

DATED JULY 5th, 1871.

1748 J. Oxley—Cask washing machine
1749 M. Wilson—Sink traps
1750 S. R. English—Sash fastenings
1751 J. Swift—Spinning
1752 F. J. Chatfield—Fire grates
1753 J. Hinchliffe—Furnaces
1754 J. Baker—Waterclosets
1755 G. S. Hinchliff and C. P. L. Chapman—Sights for ordnance
1756 H. E. Newton—Railway wheel
1757 G. B. Galloway—Roads, &c.
1758 W. Dewar—Machine for digging
1759 J. Taylor and J. Prest—Glazing saw hlades

DATED JULY 6th, 1871.

1760 R. C. Munson—Lubricating
1761 J. Farrel—Fireproof safes
1762 G. Milburn—Rugs
1763 A. Field—Candles
1764 E. Edwards—Metallic hands
1765 W. Strang—Looms
1766 L. Dunecommun—Winder for clocks
1767 W. Blackburn—Brackets
1768 G. Gulliver—Securing knobs
1769 H. R. Marsden—Breaking stones
1770 W. E. Newton—Ordnance
1771 J. J. Brock—Moustache protectors
1772 T. A. Willson—Lenses
1773 W. Bouch—Engines
1774 W. Houghton—Cleaning grain

DATED JULY 7th, 1871.

1775 H. Harrison—Sizing yarn
1776 B. Tanner—Superphosphate of lime
1777 J. Brough—Vacuum pans
1778 P. J. Livesey—Thread spools
1779 H. Philpot—Application of centrifugal force
1780 E. and H. Haynes—Reels
1781 J. Harle—Cutting metal
1782 D. Greig and R. Burton—Transport of produce
1783 A. Tibbitts and E. Fullwood—Paving streets, &c.
1784 H. E. Brown—Carriages
1785 J. Hodgart—Presses
1786 L. A. Brode and G. Bash—Bobbins

DATED JULY 8th, 1871.

1787 A. Henderson—Piston packings
1788 T. Richardson, J. W. Richardson, and A. Spencer—Furnaces
1789 T. Bailey—Firearms
1790 G. A. Ermen—Firearms
1791 E. and A. Priest—Carding engines
1792 H. A. Mallock—Electric conductors
1793 T. Butterworth—Spinning tobacco
1794 P. E. Kaeuffer—Freezing machines
1795 R. Skinner—Artificial stone
1796 W. R. Lake—Steam boilers
1797 T. Whitwell—Valves
1798 R. Hornsby and J. E. Phillips—Reaping machines

DATED JULY 10th, 1871.

1799 G. H. Ellis—Garden rollers
1800 A. Bennett—Door bells
1801 J. A. Wanklyn and W. Eassie—Preservation of milk
1802 E. Edwards—Kneading
1803 D. Shive—Governors, &c.

DATED JULY 11th, 1871.

1804 W. Hollinshead—Lighting railway carriages with gas
1805 J. Purves—Ashes hoist
1806 I. Baggs—Ice safes
1807 W. Spence—Roasting pyrites
1808 F. J. Rowan—Cars for tramways
1809 G. H. Bachhoffner—Lamps
1810 A. Strauss—Jars
1811 F. J. Manceaux—Cartridges

DATED JULY 12th, 1871.

1812 W. F. Smith and A. Coventry—Tools for turning metals

SPOKE SHAPING OR COPYING MACHINE,

BY ALLEN RANSOME & Co LONDON.

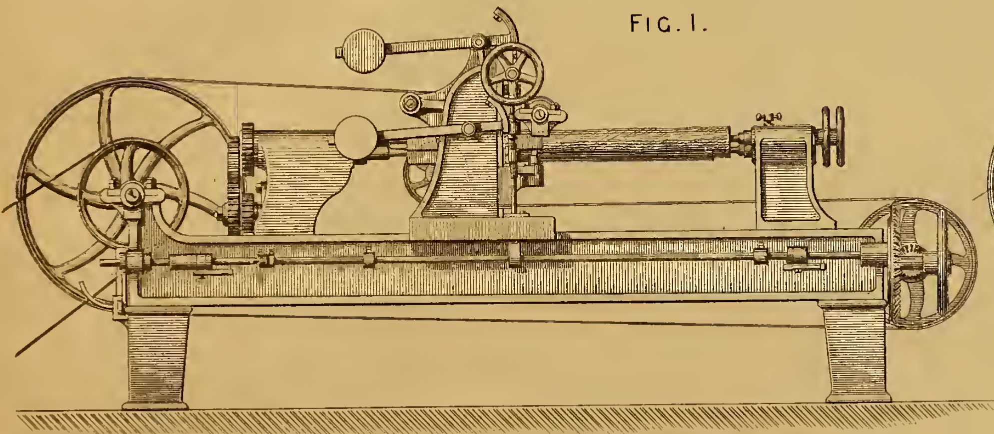


FIG. 1.

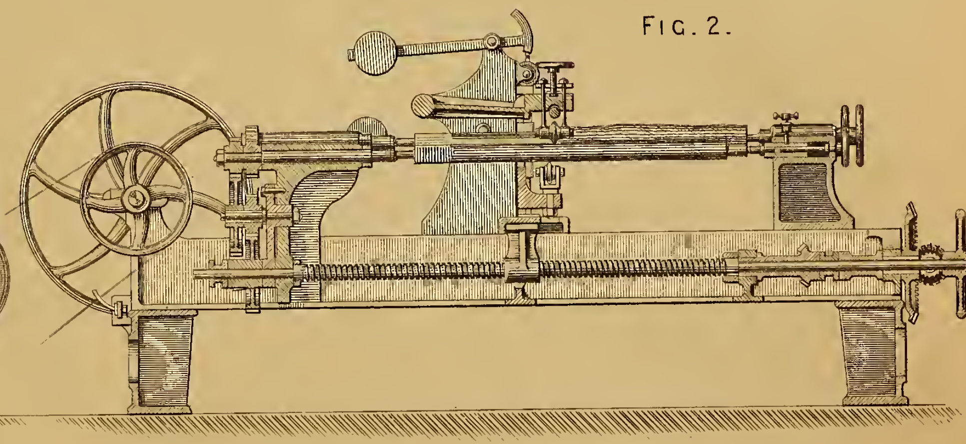


FIG. 2.

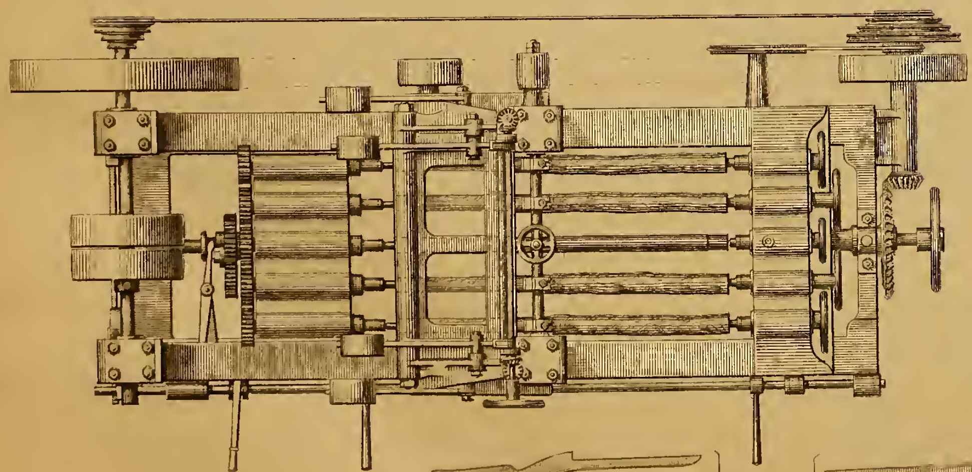


FIG. 3.

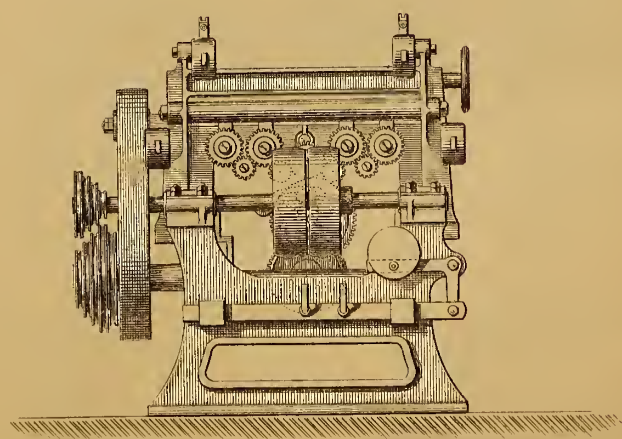
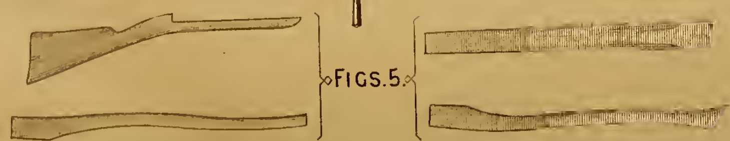


FIG. 4.



FIGS. 5.

SCALE — ½ INCH = 1 FOOT

P. Soames A.K.C. direx. G.B. Smith, sc

THE ARTIZAN.

No. 9.—Vol. V.—Fourth Series.—Vol. XXIX. From the Commencement.

1st SEPTEMBER, 1871.

IMPROVED SPOKE-MAKING MACHINE AT THE WOLVERHAMPTON SHOW.

By Messrs. Allen Ransome and Co., London.

(Illustrated by Plate 377).

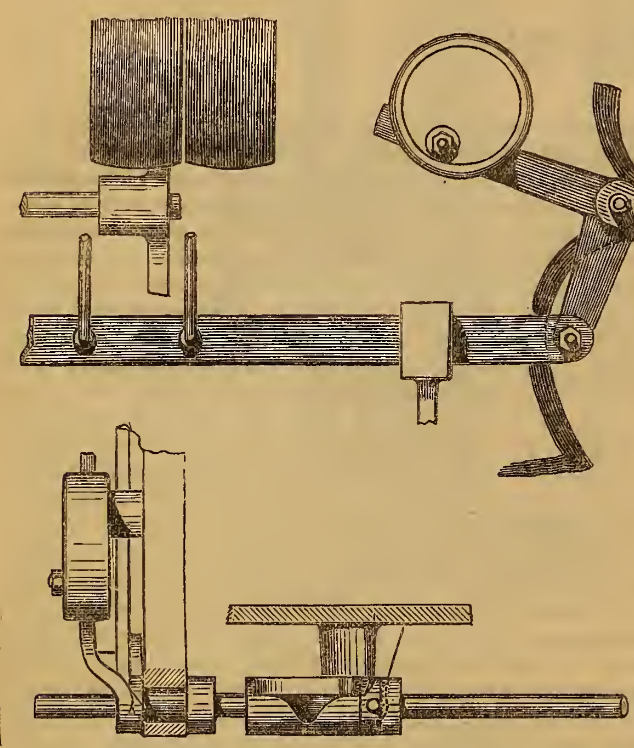
Amongst the various machines exhibited at the Royal Agricultural Society's Show at Wolverhampton, last July, few, if any, attracted so much attention as the spoke machine, which was shown at work at the stand belonging to Messrs. Ransome and Co., of Chelsea, the well-known makers of wood-working machinery. Although the inventors term it a spoke-making machine, it will turn out with equal facility wood shaped to almost any conceivable form, the only reqnisite being that a pattern of such particular form should be supplied to the machine from which to copy. Thus, when working at the Wolverhampton Show, it was turning out with great rapidity hammer shafts and axe handles, as the inventors doubtless considered that such forms would be more readily appreciated in that locality; and from the astonishment and interest depicted upon the countenances of the visitors at the apparent ease and rapidity with which these objects were manufactured, they were evidently correct in their choice.

The machine which is illustrated in Plate 377 appears at first sight somewhat complicated, but this is chiefly owing to the fact that it is intended to turn out four complete pieces at one operation; and, as each piece requires its own gearing, the number of cog wheels, &c., are correspondingly multiplied. As, however, the arrangements peculiar to each separate piece are never varied, the management of the machine is as simple as if only one model was turned out at each operation.

The principle of the arrangement is essentially that of a copying machine, but instead of only being able to move the copying tool while the model remains stationary, the model itself is caused to revolve, and thus all sides are equally accessible to the cutter. In Plate 377, Fig. 1 shows a side elevation, Fig. 2 a sectional elevation, Fig. 3 a plan, and Fig. 4 an end elevation of the machine. It will be seen from these that the machine is driven by a strap rnnning over the fast and loose pulleys on the cross shaft at the lcft-hand end, to which is also attached a large strap pulley for driving the cntters, and also a cone gut pulley for actuating the traversing gear of the cutters, and also the revolving gear for the model and the pieces of wood to be shaped similar to it. The cutters, which are carried on the cross shaft, running in long steel bearings attached to the traversing frame shown on the centre of the machine, are driven by a strap from the large pulley, which is kept tight during the traversing motion by being taken round a pulley at the other end of the framing of the machine, and also round a jockey pulley. These cutters are driven at a very high speed, usually about 4,000 revolutions per minute. The bearings in which the revolving spindle of the cutters is fitted are made to slide up and down in the upright framing, and balanced by levers and weights at each end. Besides the four cutters—one to each piece of wood to be shaped—this spindle also carries a smooth roller, which bears upon the model placed in the centre, and which serves as a guide to the framing carrying the spindle. Thus, while this framing traverses longitudinally the smooth roller bears upon the centre model, and causes it to rise and fall with its ineqnalities, a corresponding rise and fall being imparted to the cutters; and hence, whatever shape the model may be, it is imparted to the pieces of wood by the action of the cutters. In order to keep the working of the machine steady during the traversing motion of the cutters, a series of rests—one under each piece of wood, and also under the model—are attached to a cross sliding frame underneath, slightly behind the cutters, and caused to press upwards by means of a weighted lever. These rests have a slight amount of play given to them by means of spiral springs being placed underneath them. By this means the work is kept from springing whilst being operated upon. The traversing motion is imparted to the upright frame carrying the cutters above and the rests below the wood, by means of a screw actuated by the bevil wheels shown at the right-hand end of the machine, and driven by means of the gut cone pulleys already described. In addition to the revolving and forward motion thus given to the cutters, the metal model and the pieces of wood to be shaped are caused to revolve slowly by means of a set of spur wheels attached to the back of their respective headstocks, these wheels being driven from gearing keyed on to the traversing screw. As it is necessary to vary the speed of this revolving motion with the different shapes to be formed, a set of change wheels somewhat similar to a screw-cutting lathe is provided for that purpose. The speed of the traversing motion may also be varied by means of the cone pulleys upon which the gut band works. The spindle which carries the cutters is made of steel, and works in long self-lubricating bearings. The speed of the traversing frame carrying the cutters may be varied from two to four feet in a minute, and when the work is completed it is returned at a speed of about thirty feet per minute. The quick return speed is effected by throwing out the bevil gearing at the end of the machine by means of a clutch sliding on a feather on the screw, and putting into gear by a similar method a quick motion attached to the gut pulley shown in the plan Fig. 3, Plate 377. During the return motion the cutters above and the rests below the work are withdrawn from the work by means of a spindle with a right and left-handed screw, as shown in Fig. 1.

The method of working the machine is extremely simple. The pattern, which is usually made of cast or wrought iron, in order to obtain snfficient stiffness, is placed between the two headstocks, which are similar to those of a common lathe, in the centre of the machine. The four pieces of wood are also fitted to their respective headstocks on either side of the model, the cutters being placed at the end of these pieces. The machine is then started, when the cutters begin immediately to revolve rapidly, and at the same time to slowly advance towards the other end of the pieces of wood. At the same time the model and these pieces slowly revolve, and as the cntters followed by the rests advance they rise np and down in accordance with the inequalities of the pattern upon which the smooth roller, acting instead of a cutter, advances upon the iron model. Thus, by means of the traversing and revolving motions the cntters act upon the entire surface of each of the four pieces and, being entirely guided by the centre model, copy exactly the shape which that bears. It is evident that instead of four a greater or less number of pieces of wood may be shaped at one and the same time by multiplying or lessening the number of headstocks. We need only add that when we saw it in motion, at Wolverhampton, it appeared to perform its allotted work remarkably accurate and well.

In the accompanying engraving is shown an ingenious method of making the machine self acting so far as regards stopping when the work is finished. The two views show a side and end elevation of this arrangement. It will be seen that it consists of a groove, shown in dotted lines, which is cut in a box placed on the starting rod, into which



a pin fixed on the side frame is fitted, and which prevents the rod from turning. At the middle of the groove a slot upwards is formed, so that when the starting rod is in such a position that the pin is in the centre the weight at the end causes this rod to revolve partially. As the crank at the end of the starting rod is connected to the shifting gear of the strap, this motion causes the strap fork to shift the strap from the fast to the loose pulley, and thus stop the machine. This motion of the starting rod is obtained by placing a dog at the required distance on the other end of the machine, in a similar manner to that used on planing machines; and when the slide carrying the cutters has travelled a sufficient distance to complete its work it comes against this dog and moves the starting rod so as to allow the weight to fall and stop the machine. In order to start it again, when the slide has been returned, a lever handle is used in the usual manner. By this arrangement any injury to the machine through the carelessness or inattention of the attendant is obviated.

INTERNATIONAL EXHIBITION.

Hodgson's Wire Tramway.

Those of our readers who have visited the International Exhibition have most probably seen in the grounds outside the building, contiguous to the machinery department, a series of packages, baskets, pails, &c., ceaselessly gliding along in mid-air from one end to the other of a tolerably long grass plot. The ease with which these packages appear to travel, together with the simplicity of the machinery employed, at once stamps it as being a valuable addition to the numerous methods of transport already familiar to us. The idea of an overhead tramway for the carriage of passengers and goods across a river or ravine is very old, and has been in use in India and China from time immemorial, the basket used for conveyance being hauled across a standing rope from one side to the other, as occasion required. In these cases, however, no intermediate support for the conveying rope could be employed, and consequently their use was limited to a single span; besides, the entire arrangement was so thoroughly primitive that it could only be advantageously used in cases of direct necessity.

The wire tramway at present under notice, and which was invented by Mr. Charles Hodgson a few years ago, has apparently been suggested by these rude methods of transit, but at the same time he has overcome the objections to the original form. As we have already mentioned, the great objection to the old method of aërial transit was, that the goods traversing along it could only pass from one fixed erection to another, and consequently the space to be travelled was limited by the distance between these two erections. Such an arrangement is evidently only suitable to very short distances. In the present invention, however, any number of posts for carrying the wire rope may be employed without obstructing in the slightest degree the passage of goods from one terminus to another, and consequently the distance between these termini is unlimited.

Although we have endeavoured to compare Mr. Hodgson's wire tramway with the rude appliances used in India, it is so entirely modernised that the similarity between them is very slight. Thus, instead of being worked by hand, it is driven by an engine, while the rope, instead of being made of hemp, is constructed of steel or iron wire.

The accompanying engravings illustrate Mr. Hodgson's method so completely that but little explanation is required. Fig. 1 shows a general view of a portion of a line of tramway, including two of the supports similar to those shown at the Exhibition. These supports may, of course, be made of iron, if preferred. Two packages are also shown, one traversing the up line and the other the down line of the tramway. These packages are simply placed anywhere upon the moving wire rope, and carried to their destination. The simplicity of this operation will be more clearly understood upon referring to Figs. 4 and 5, which give an enlarged sectional view and elevation respectively of the carrier. It will be seen that the carrier proper consists simply of a piece of hard wood, with a longitudinal groove cut in the underside to "take into" the rope. As this groove encircles barely half the upper circumference of the rope, and as the pulleys on the standards supporting the rope enclose less than half the underside, the carriage when passing over a pulley does not touch it. This, we consider, is one of the chief merits of the invention, as no elaborate machinery for clearing the stationary pulleys is required; but the block, or saddle, simply rides over the top, without touching anything. It might be thought that these saddles would be apt to slip on the rope, but it has been found that the friction is amply sufficient, even for very steep gradients. In order to provide against the chance of slipping on one side when passing over the pulleys, the saddles have a wrought-iron check fitted on each side, one of which would bear against the pulley should the saddle be thrown out of its direction.

The packages are carried by a bent arm, shown (broken off) in Figs. 4 and 5, attached to the saddle, and brought down to any convenient length. By making a second bend in these arms, so as to return the hook exactly vertically with the rope, the load is maintained in perfect equilibrium, and at the same time clears the pulleys. When used for carrying sugar-canes, or similar articles, they are forked, and formed at their lower end into a semicircular shape, upon which the canes are placed and carried to their destination. The arrangement for each terminus is shown in Figs. 2 and 3, and is very ingenious. The wire rope is carried round a large horizontal, or nearly horizontal V sheave, which is driven by bevil gearing and strap pulleys from an engine in the usual manner. When the goods arrive at the terminus the two small grooved wheels attached to the saddle, and shown in Figs. 4 and 5, are brought

on to a semicircular race, and as the wire rope descends by the inclination of the large V sheave, it leaves the saddle, and the weight of the goods is carried by these rollers. The impetus of the package causes it to be carried round on these rollers to the other end of the semicircular portion of the race, where they are removed. This being done fresh

Fig. 1.

goods may be loaded on the carrier, or the carrier may be forwarded empty, by simply pushing it to the end of the straight portion of the race, when the saddle falls into its place on the wire rope, and is forthwith conveyed back to the other terminus. The rope is thus never

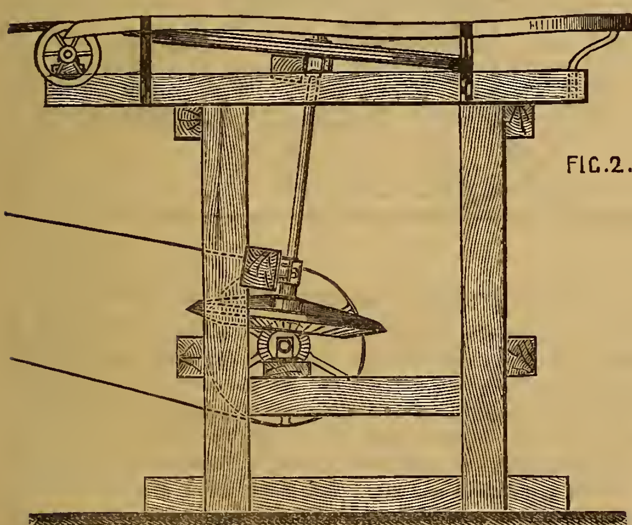


FIG.2.

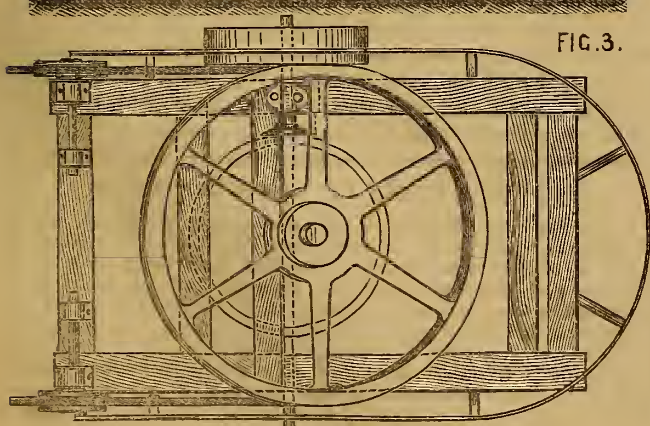
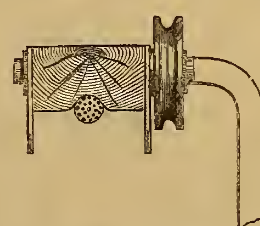


FIG.3.

required to stop, the delivery of the packages being continuous. The amount of force required for pushing the packages along the straight portion of the race is very slight, and it may easily be done by a boy. The posts for supporting the wire are ordinarily placed about 300ft. apart, but where the nature of the country necessitates a longer span, a distance of 1,000ft. is often employed. The boxes or packages are made to carry from one to ten hundredweight, according to the strength of the rope, and the delivery is at the rate of about 200 per hour for the entire distance. As curves even of a small radius are easily passed, it is not necessary that the rope should be carried in a straight line. It has been found that inclines of 1 in 7 are admissible on this system, the friction between the saddle and the rope being sufficiently great to prevent slipping.

From the above description it will be seen that this system possesses great advantages for the carriage of goods in hilly or otherwise difficult countries. Thus, no bridges are required for crossing ravines or rivers

FIG.4.



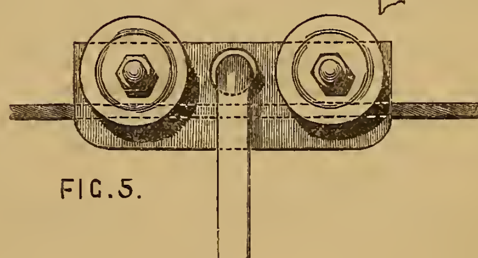


FIG.5.

and no cuttings or embankments are necessary on hilly ground; moreover, the amount of land actually occupied is very trifling, a post every 300ft. being all that is required, excepting at the stations. Another advantage may be mentioned, viz., that when passing over undulating land the extra power required for causing the loads to ascend an incline is obtained by the gravity of the descending loads upon other portions of the line, and thus, as the loads ascend and descend they mutually assist each other's passage.

The Company have already about twenty-five lines at work in various

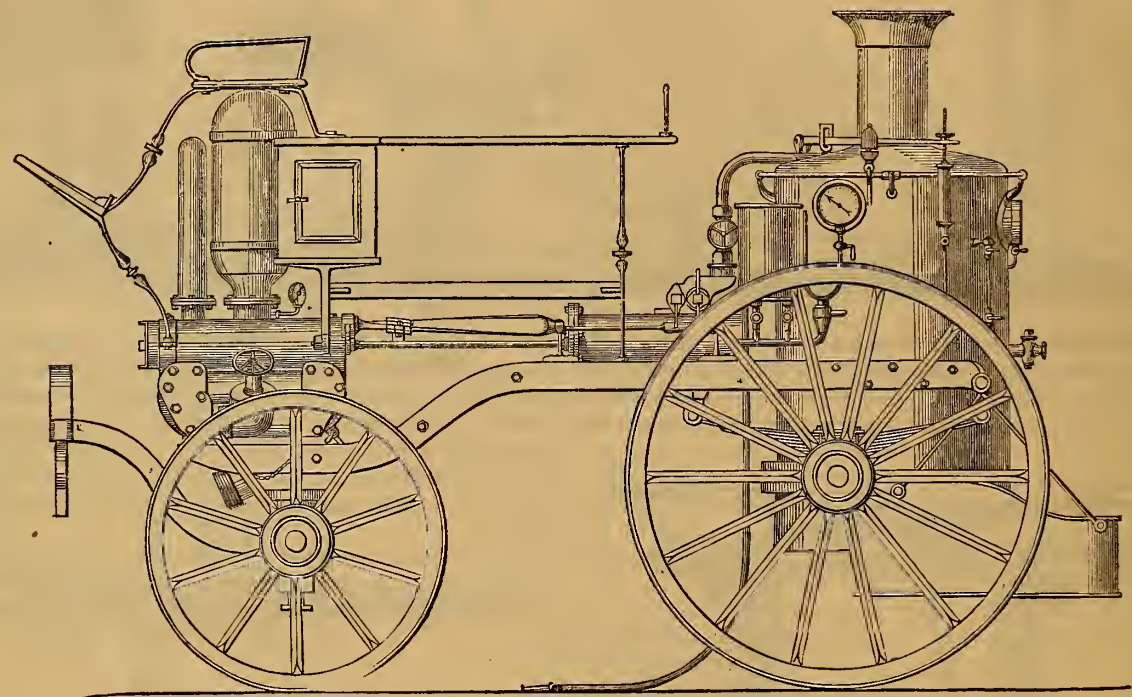
parts of the world; one at Prague, which is used for carrying beet-root, has an incline as much as 1 in 2 upwards. We also understand they have about as many more lines in various stages of progress.

STEAM FIRE ENGINES FOR THE HAGUE AND ROTTERDAM.

Messrs. Merryweather and Sons have just completed a steam fire-engine for each of the above towns, which is illustrated in the accompanying engraving. The authorities, after having made the steam fire-engine a question of considerable debate, and comparing the machines produced by both English, American, and continental makers, decided upon the class of engine that is peculiar to the above firm, and for the merits which it possesses—simplicity, durability, and accessibility to all parts in case of repairs; as, also, only a man of ordinary knowledge, and not necessarily a mechanic, is required to attend to it.

The Hague steam fire-engine weighs 2,800lbs., raises steam from cold water in eight minutes from the time of lighting the fire, so that a gas-jet, which by all practical engineers is considered so injurious to a boiler, will not be required in the fire-box. The diameter of the steam cylinder is 6½in.; diameter of the pump, 5¼in.; stroke common to both, 18in. The Government regulations do not admit machinery to work beyond 100lbs. on the square inch; Messrs. Merryweather's engine is, therefore, just adapted for them, as upon this basis they calculate the performances of their machines. The engine is very complete in all its details; having four different ways of feeding the boiler, there is no fear of any mishap on the score of shortness of water, and nothing less of gross and culpable neglect could cause the boiler to be short of this element. The feed arrangements are—1st, by Giffard's injector; 2nd, by feed-pump working direct; 3rd, by feeding boiler from the steam fire-engine pump, and discharging its whole contents at each stroke into the boiler (nearly three gallons); and 4th, by hand feed-pump. The above engine discharges 300 gallons per minute, 160ft. high, and 200ft. distance.

The Rotterdam engine has a pair of steam cylinders each 6¾in. diameter, and the pumps each 5½in. diameter, with stroke of each 18in. It is fitted so as to meet the Government requirements as in the case of the Hague engine, and will discharge 600 gallons per minute to a height of 180ft., or 240ft. horizontally; will work eight ⅞in. jets each to a distance of 100ft. This engine is similar to one supplied to the Rotterdam authorities some six years since, with the exception that for its weight (4,480lbs.) it is 25 or 30 per cent. more powerful.



PATON'S IMPROVED FLEXIBLE METALLIC PACKING.

We have received a sample of the above packing, invented and recently patented by Mr. William Paton, of Johnstone, near Glasgow, which appears to be very well adapted for the purposes to which it is applicable. It consists of a combination of hemp or other vegetable fibre and fine wire plaited together over a flexible core. In the specimen before us the centre is composed of solid india-rubber, about a quarter of an inch in diameter, and over this is laid a series of moderately fine strands of jute or cotton. Over the core thus formed is plaited or braided a series of fine wire and hempen strands, alternating with each other, and forming a solid ribbed packing: the ribs being composed alternately of hemp and wire. It appears to be a very good and durable species of packing, and from what we have heard, it has given great satisfaction to those who have already tested its merits.

THE COAL FIELDS OF NEW SOUTH WALES.

In the *Newcastle* (New South Wales) *Chronicle*, of May 14, appears an elaborate report by Mr. William Keene, F.G.S., as to the state of the coal-fields of New South Wales. At a time when the question of the coal supply is engaging considerable attention, and the report of the Royal Commissioners is looked forward to, a few facts and figures from this distant land of fuel may not be devoid of interest. The first colliery in the catalogue is the A. A. Company's, Newcastle. Here the depth of working shaft from the surface to the bottom of the working seam is 186ft. 6in. The whole seam is worked, and is all of one quality. The bord and wall method of working is exclusively adopted, *i.e.*, bords, or

working spaces, are turned off four yards wide, and when four yards from the heading, are laid out to eight yards wide, the length of pillar varying from fifty to sixty yards. Headings are six feet wide. There are thirty horses and ponies employed underground at present, but an underground engine of 25-H.P. is now ready for work, hauling the coal from the dip workings, which will replace a number of the horses. There are 400 men and boys employed on the surface and underground at this pit; and between January 1st and November 22nd, 1870, there has been been raised a total of 168,483 tons of coal, of which 35,108 tons was small coal, and 230 tons consumed at the works. The average get of best coals per week is abont 3,000 tons. The next is Waratah Company's Colliery. The seam is approached by two tunnels, but only one is worked at present. The seam is of one quality throughout of good coal. The usual bord and wall system of working is adopted, the two lowest portions of the seam being worked first, and then the 2ft. 6in. of top coal brought back. Fourteen horses are employed undergronnd; no engine power. There are 144 men and boys employed, and raise at present about 150 tons per day of best coal. We then find the familiar name of Lambton Colliery; depth of working shaft, 35ft. 6in.; 9ft. diameter. The depth of the ventilating shaft is 112ft.; diameter 7ft. The depth of the sonth pit is nearly 400ft., and at the bottom of this shaft there is at present erecting the largest ventilating furnace in the colouy, having a fire surface of 200ft. area. The coal is worked on the pillar and wall principle, the bords being eight yards wide, pillars varying from three to fifteen yards. The total number of men and boys employed varies from 270 to 280; of these 230 are miners. Miners can earn on a fair average about 12s. each per day. The coal sells at the highest rates, and, with other coals from New Sonth Wales, was tested by the English Government, at the Woolwich yards, and found to be equal to good English coal. The average daily production of sound coal is 650 tons. In New Lambton Colliery the seam furnishes 8ft. 1in. of good coal, of one quality throughout, and is the same as that worked by the Lambton and Waratah Companies. The method of working adopted here is the nsual bord and wall system of the district. There are 21 horses employed underground; there is also a 12-H.P. engine underground, for hauling coal from the dip workings to a station near the working pit. There is one 25-H.P. engine at the surface, for winding coal and pnmping water from the working shaft. Direction of the dip of the seam is south to east two degrees. There are 315 men and boys employed underground, and above ground 38; in all 353. The pit is raising on the average 350 tons per day of best coal. Here, too, as on Tyneside we find a Wallsend Colliery. The depth of the pit from the surface to the bottom of the seam in this colliery is 265ft. 9in. The seam is eight feet thick, and the whole of the seam is worked, and the coal is of one quality throughout. The method of working is the usual bord and wall system of the district, *i.e.*, bords eight yards wide driven on the face of the coal for 50 yards, then bronght into six yards wide, and holed over on each side at right angles (or heading course) for 6 yards. Pillars are also taken out. There are 330 men and boys employed underground at the B and C pits, and 75 on the surface; total 405. The pits together raise 800 tons of best coal per day. The co-operative principle has apparently been applied to mining operations in New Sonth Wales, there being a colliery of this nature nnder the title of Messrs. Laidley, Ireland, and Co. A tunnel is used here for bringing the coal to the surface. The whole of the coal in the seam is worked, and is of good quality throughout. A new shaft has been lately snnk for a pumping and furnace shaft, abont 800 yards from the month of the present tunnel. The nsual method of the district is adopted here in working, viz., bord and wall, *i.e.*, bords are driven eight yards wide for 50 yards, walls 6ft. wide, pillars left four yards wide, but afterwards taken out. The next colliery is the Red Head Tunnel, Burwood, in which only 5ft. 3in. of the seam is worked at present, and is all of one quality. The pillar and wall method is adopted here, similar to that of the Australian Agricnltural Company. There are 51 men employed both nnderground and surface, and are raising on an average 80 tons per day. At Woodford Colliery the depth of the working pit is 103ft. 6in. from the surface to the floor of the seam, and the seam yields 5ft. 11in. of good coal. The bord and wall system of working is generally adopted. The coal has not yet found a market, as the colliery only resumed operations in Angnst 1870. Samples of the coal have been sent to the Sydney and Melbourne Gasworks and to the New England steamer, and their reports of the qnality of the coal are favourable. There then follow several minor collieries in which the daily average extractions range from 10 to 30 tons. Mr. Keene also states that the progress of the railway towards Bathurst has given great activity to the opening of the main coal seam in the Western District, which extends over a large area, and is abont 10ft. in thickness, the coal being of good quality. The principal trial drifts are at Bowenfells and Lithgow Valley; and when the railway shall be completed to Bathurst there will be a considerable demand for this coal. Mr. Brown, Mr. Andrew Brown, Messrs. Saywell and Garsad, Messrs. Mackenzie, Messrs. Wooley, Anderson, and Poole, are all actively engaged in efforts to develop the coal resources of the district. There is thus abundant evidence that the coal field of New South Wales is an extensive and frnitful one; and from the conclnding words of the roport—"other mines as they may be opened will be reported"—it may be inferred that the resources admit of yet much greater development.

NOTES ON THE PRACTICAL PHOTOMETRY OF COAL-GAS.

By Dr. Wallace.

The following arrangement of the different parts of the photometric apparatus has been found convenient, and has been so highly approved of by those who have seen it that it is thonght worthy of a brief description. The meter is not placed at the end of the photometer bar at which the gas is burned, but towards the candle end, and immediately below that part of the bar where the observations are usually made; and attached to the outlet is a three-way stop-cock with lever handle, the side branch of which is connected by a few inches of pipe with the inlet, so that the gas may be passed through the meter, or direct to the burner, as may be desired, the gas being, in either case, kept constantly burning. At the candle end, and on a level with the photometer bar, is placed a small shelf supporting the candle balance; and this is arranged so that the candles have to be moved only a few inches into the receptacle at the end of the photometer. The gas is now passed through the meter until the hand comes to zero, and the stop-cock is tnrned so as to pass the gas direct to the jet. The clock, which is either attached to the meter or placed immediately beside it, is also adjusted, and the candles are nearly counterpoised. At the moment when the balance turns, the operator with one hand turns the stop-cock, with the other sets the clock in motion. The candles are now placed in, position, and by the end of the first half minute the operator is ready to take the first observation. The sight-box has in front of it stereoscopic lenses, so as to shorten the focus of the eyes, and make the images of the two sides of the disc more distinct, at the same time that they coalesce or overlap one another. By this means great accuracy of observation is attained, and the influence of the different colours of the two flames is entirely removed. Two circnlar screens of very light wood, 18 inches in diameter, strengthened by cross-bars and having in the centre openings 4 inches square, are fixed on the photometer, one on either side of the sight-box and about 20 inches apart, and the sight-box is provided with two side flaps of thick vnlcanised india-rnbber; the object of these arrangements being to prevent the possibility of any light passing to the eyes of the operator but that reflected by the mirrors in the sight-box. At the end of the tenth minute the stop-cock of the metre is reversed, and, at the same moment, the candles are extinguished; after which the operator leisurely notes the consnmption of gas and the loss of weight of the candles. The advantage obtained by this arangement is that the gas examiner does not require to move from his position opposite the meter during the whole experiment, while the meter is read off only when stationary. The stereoscopic sight-box is not an essential part of the apparatus, and requires great care in the adjustment of the lenses, but when these are carefully fixed the results are highly satisfactory. In the arrangement above described, the governor is placed immediately to the right hand of the meter (supposing the gas to be bnrned at the right side of the photometer) and the King's pressure gauge at the left-hand side, so that both are readily observed or corrected. The pressure at which it has been found best to burn the Glasgow gas (28 to 30 candles) is from four to five-tenths, and the standard Cannel batswing supplied by Sugg is employed at all testing stations. In order to prevent evaporation, the surface of the water in the meters, pressure gauges, and governors, is covered with a layer of about $\frac{1}{16}$th. of an inch of "intermediate" paraffin oil. This oil has gravity of 850 to 860, and a firing point of about 250° F., and does not effect the illnminating power of the gas, nor does it thicken by exposure to cold. In the estimation of the snlphur in coal-gas it is usual to cnt off the gas, by means of a pin acting on a lever, at 10 cubic feet, but it is more advantageous to adopt 13·7 cubic feet as the quantity, as in this case the number of grains and fractions of a grain of barium snlphate obtained represents the number of grains of sulphur in 100 cnbic feet of gas. The half of this quantity, or 6·85 cubic feet, may also be taken, but in this case the quantity of barium sulphate must be multiplied by two. The apparatus used in Glasgow is that of Dr. Letheby, with the addition of a second cylinder of about twice the capacity of the first. The estimation of ammonia is made by means of a very simple apparatus. A tray of copper coated with paraffin, or, still better, one of porcelain, about 12in. long by 4 wide and 1in. deep, has inverted in it a similar vessel $11\frac{1}{2}$in. long, $3\frac{1}{2}$in. wide, and nearly the same depth as the tray. At each end of the inverted vessel is a coupling, so that the gas to be used in the sulphur estimation can be passed through this apparatus before going to the burner. Into the

tray is placed 100 measures of a test-liquid consisting of dilute sulphuric acid of such strength that this quantity would be exactly neutralised by 13·7 grains of ammonia, and water is added, if necessary, to give a depth of about a quarter of an inch of liquid. 13·7 cubic feet of gas are now passed through the apparatus in the usual manner, after which the contents of the tray are transferred to a white porcelain basin, and the tray and inverted vessel washed by means of a washing bottle, and the washings added. Some tincture of litmus is now added, and from a burette is dropped, with constant stirring, a solution of caustic potash, 100 divisions of which correspond exactly to 100 divisions of dilute acid. When the blue colour of the litmus is restored the number of divisions consumed is read off, and the difference between it and 100 divided by 10 gives the number of grains of ammonia in 100 cubic feet of gas. The absorption of the ammonia is so perfect that not a trace can be detected by afterwards passing the gas through the ordinary bulbs filled with beads or broken glass.

COMMUNICATION WITH AUSTRALIA.

Mr. Baillie Cochrane has published a correspondence between himself and Mr. Monsell, the Postmaster-General, with reference to a proposal for the establishment of a new line of steamers to Australia *viâ* the Cape. In his communication to the Postmaster-General, Mr. Cochrane states :—" Without in any way undervaluing the overland route, there are manifest advantages by the Cape. The distance to Melbourne is within a few miles the same ; the *Great Britain* now performs the voyage in 55 days, and in suitable steamers it may be accomplished in 45 days. Vessels of 4,000 tons will afford accommodation at low rates for the younger sons of men of family, and of that class it is of so much importance to reach—third-class emigrants. The fares would be, third class £15, second class £40, and first class £60, the painful sense of distance would be diminished ; this route would not be affected by troubles in the East, and the dangerous voyage of the Red Sea would be avoided. A subsidy of £80,000 will do all that can be required, and this is not much to ask after the great economy that has been made by the withdrawal of the troops. Assuredly we should do all in our power to bind our colonies to the mother country, and I am sure the Executive desire to do so. The colonists cling in all things great and small to the mother country. A colonist told me, the other day, that in the wildest parts of the back settlements copies of the *Times* and *Illustrated* may be found. By these new steamers you will creat a fleet worthy of your colonial empire, and Great Britain will more and more closely bind herself with what the hon. member for Chelsea truly called Greater Britain."

The Postmaster-General, in his reply, points out that steamers fitted to carry large numbers of emigrants through the tropics would not be fast enough for postal service ; and remarks that cheap, expeditious, and frequent postal communication is the strongest and surest means to bind together the colonies and the mother country. He professes his anxiety to secure this union between the colonies and the mother country ; and proceeding to consider the subject of postal facilities with Australia on its own merits, he says :—" The New Zealand Government have made a contract for thirteen complete services in the year between San Francisco Auckland, Sydney, and Melbourne. If this were used to alternate with the Suez line as a fortnightly service, the colonies first served by the Suez line would be the last served by the San Francisco line, and *vice versa*. As it is impossible to establish separate conveyances to each colony, we must decide upon the routes that best suit them as a whole. The Cape route would generally serve first those first served by the Suez route. It would be fairer therefore, to adopt the San Francisco as a second route than the Cape. These, however, are matters upon which it would be desirable to know the opinion of the Australian colonies. I doubt whether your anticipation of a 45-day passage to Melbourne by the Cape will be realised. Still more do I doubt whether it will be realised by vessels capable of carrying emigrants in safety and comfort across the line. The average time taken by the *Great Britain* is about 57 days. The *Queen of the Thames* took 62 days. The contract time by Suez is 48 days."

The following letter to a contemporary refers to the above :—

" SIR,—With reference to the important article which appears in your paper of this date, under the heading 'Communication with Australia,' giving extracts from the correspondence which has passed between Mr. Baillie Cochrane and the Postmaster-General with reference to a proposal for the establishment of a new line of steamers to Australia *viâ* the Cape, will you permit us to state, for the information of Mr. Cochrane and Mr. Monsell and others interested in this matter, that several steamers capable of accomplishing the passage within the time named by Mr. Cochrane (45 days) have been produced within the last few years. We have ourselves constructed eight steamships of over 3,000 tons each, all of which could do this. As regards the doubt expressed by Mr. Monsell as to the possibility of obtaining this speed in steamships adapted for the conveyance of emigrants at moderate rates in safety and comfort, there is no longer any room for entertaining it. We are quite prepared, on receiving an order from any respectable firm or company, to undertake the construction of steamships which will carry emigrants to Australia *via* the Cape more safely and in greater comfort than has ever yet been done, and in a shorter time—say, within 40 days.

" We are, &c.,

" Glasgow, 22nd August, 1871. JOHN ELDER and Co."

THE MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last Ordinary Monthly Meeting of the Executive Committee of this Association was held at the Offices, 41, Corporation-street, Manchester, on Tuesday, July 25th, 1871, James Petrie, Esq., Rochdale, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, which on that occasion was for two months, and is given in abstract as follows :—

Since the last meeting of the executive committee of this association, the report from the select committee of the House of Commons appointed to inquire into the cause of steam boiler explosions, and the best means of preventing them, has been presented. The following is a copy :—

" The select committee appointed to inquire into the cause of steam boiler explosions, and who were subsequently empowered to inquire as to the best means of preventing them ;—Have considered the matters to them referred, and have agreed to the following report :—

" 1. A select committee was appointed on the same subject on the 16th May, 1870 ; they commenced their sittings on the 14th June, and sat during many days until the 21st July, when they reported to the House the evidence which they had taken, and recommended the re-appointment of the committee this session. On the 16th of March of this year your committee commenced their labours, and concluded the evidence on the 25th April.

" 2. Much evidence has been received which is important and valuable. The witnesses agree mainly as to the causes of boiler explosions, but their recommendations on the subject of prevention are very conflicting.

" 3. The attention of your committee has been most pointedly and earnestly called to the existence and working of several voluntary associations, formed with a view of ensuring the periodical inspection of steam boilers, and your committee have reason to believe that these associations have been useful in preventing explosions.

" 4. It has been urged on your committee that a further reduction in the number of explosions might be effected by an extension of the surveys of voluntary associations ; but your committee consider that inspection could only be made general by being made compulsory.

" 5. Your committee cannot omit to emphasise the fact, that steam boilers are in many instances situated in much frequented part of towns and cities, under pavements in crowded thoroughfares, in the lower storeys of houses, and in the midst of crowded dwellings.

" 6. That these boilers are often faulty in construction, are frequently so placed that inspection without removal is impossible, are without proper gauges and necessary equipments, have exposed safety-valves, whereby the pressure can be increased to a dangerous extent by any one having access to the boiler, and are too often worked by men who are ignorant of almost everything connected with a steam boiler beyond the mere act of keeping up a fire.

" 7. It is the duty of a steam user to take every step in his power to procure a trustworthy boiler in the first instance ; to have it supplied with proper fittings, and to see that it is worked by a competent and sober man, at a safe pressure, and to keep it periodically examined, and always in good repair.

" 8. From the evidence given, it appears to your committee that there are in the United Kingdom not less than 100,000 steam boilers (exclusive of boilers in locomotive engines, steam ships, and of domestic and bot-house boilers), and that these are not only used in mills and manufactories, but largely in agriculture, and even in the hearts of crowded cities.

" 9. So far as your committee have been able to ascertain, it appears that the average number of explosions per annum is 50 ; and that the average number of lives lost from these explosions is 75 per annum, in addition to which a larger number of persons annually sustain injury.

" 10. That the majority of explosions arise from negligence, either as regards original construction, inattention of users and their servants, neglect of proper repairs, thoughtlessness in setting, and absence of proper and necessary fittings.

" 11. That your committee have not failed to weigh carefully, and to give due consideration to, the suggestions made to them in various forms,

that all steam boilers should by statute be inspected periodically. They are, however, not prepared to recommend the adoption of any system founded upon the theory of compulsory periodical inspection; it appears—

"(a) That the explosions at present number about 50 per annum, or at most one explosion in 2,000 boilers; (b) That a great number of these explosions arise from causes independent of and apart from anything that could be prevented by periodical inspection; (c) That it is doubtful whether compulsory inspection would not lessen the responsibility of the users, who are best able to ascertain the condition of their boilers, and the competency of the men employed to work them.

"12. It appears to your committee that the coroner's jury, as generally constituted, cannot without the assistance of competent and independent professional advice, satisfactorily investigate the causes of steam boiler explosions.

"13. Your committee therefore recommend—

"(a) That it be distinctly laid down by statute that the steam user is responsible for the efficiency of his boilers and machinery, and for employing competent men to work them; (b) That in the event of explosion, the onus of proof of efficiency should rest on the steam user; (c) That in order to raise *primâ facie* proof, it shall be sufficient to show that the boiler was at the time of the explosion under the management of the owner or user, or his servant; and such *primâ facie* proof shall only be rebutted by proof that the accident arose from some cause beyond the control of such owner or user; and that it shall be no defence in an action by a servant against such owner or user being his master, that the damage arose from the negligence of a fellow-servant.

"14. That whenever an explosion happens to a boiler, whether such explosion is or is not attended with loss of life or injury to person or damage to property, it shall be the duty of the user to report the same to the coroner of the district; and the coroner to whom the accident is reported, or in failure of such report, on the fact coming to his knowledge, shall hold an inquiry, and apply to the Board of Trade, and the Board of Trade shall thereupon direct one of their competent practical surveyors of boilers, or some other practical person, to assist the coroner in the investigation.

"15. That the coroner shall report the result of each investigation to the Secretary of State for the Home Department, and that such reports be annually presented to Parliament.

"20 June, 1871."

This report will no doubt be regarded by the members of the association with some satisfaction, but at the same time with some dissatisfaction. It is satisfactory that the committee has arrived at the conclusion that the majority of explosions arise from negligence, either as regards original construction, inattention of users and their servants, neglect of proper repairs, thoughtlessness in setting, and absence of proper and necessary fittings. The committee has thereby accepted the principle this Association has so long laboured to impress on the public, viz., that steam boiler explosions, as a rule, are not the result of chance, that they are not mysterious in their origin, that they do not happen alike to the careful and the careless, that they are not accidental but that they are preventible, and arise from the simplest causes. That in a word they are the result of neglect, that neglect being due to one of three parties, viz., the boiler maker, the boiler master, or the boiler minder, some boilers bursting because they were malconstructed in the first instance, others because they were worked on till worn out, and others again because the water supply, &c., was neglected through default of the attendant. These are the views which this association has persistently advocated, and something has been gained by their being stamped with legislative approval. This acknowledgment may form a basis for future action. It is further satisfactory that the committee has arrived at the conclusion which the Association has so strongly urged, that the coroner's jury, as generally constituted, cannot, without the assistance of competent and independent professional advice, satisfactorily investigate the causes of steam boiler explosions. On the other hand, the association cannot regard with satisfaction the statement, that a great number of explosions arise from causes independent of and apart from anything that could be prevented by periodical inspection, since its experience shows that six explosions arise from the badness of the boilers, to one from the neglect of the attendants; while even though one-seventh of the gross number of explosions may be attributed to the neglect of the attendants, a considerable proportion of that seventh is at the same time greatly due to the omission of a suitable complement of fittings, the adoption of which would be promoted, as well as greater care on the part of the attendants stimulated, by periodical inspection, and thus the number of explosions, now laid at the door of the attendant, still further reduced. The association will further regard with dissatisfaction the statement that the users are best able to ascertain the condition of their boilers. This statement cuts at the root of independent periodical inspection, which has done so much towards the prevention of boiler explosions. Users of boilers, however competent as men of commerce, are, in the majority of cases, incompetent to inspect their own boilers, not only from the want of technical experience, but from the pressure of other duties. To such, competent independent inspection is of great service, and it will be thought strange by the members of this association, who have experienced the practical advantages of such a system, that any slight should be cast upon it by a Parliamentary Committee, inquiring into the best means of preventing steam boiler explosions. It must be clear that if explosions are to be prevented it must be by the spread of independent periodical inspection, and thus by the direct contradiction of the report in question. It will be seen that the select committee recommend that the steam user be subjected to pains and penalties in the event of his allowing his boiler to give rise to an explosion, in preference to recommending a system of compulsory inspection which would help him to prevent the occurrence of these catastrophes. The consideration of the relative advantage of these two systems,—the one, that of punishment, and the other, that of prevention, is a long one, and cannot be entered upon in this report, though this may be done on a future occasion. But it will be of interest to compare the statements of the committee, to which reference has just been made, with the facts met with by this association in its recent rounds of inspection, and it was with the view of facilitating this comparison that the report of the boiler committee has been introduced before entering on the consideration of the results of the inspections of the last two months, the particulars of which may now be given.

Return of Inspections and Defects.

During the past two months 403 visits of inspection were made, and 838 boilers examined, 471 externally, 18 internally, 10 in the flues, and 339 entirely, while in addition 2 new boilers were tested by hydraulic pressure, as well as specially examined, both as regards their construction and complement of fittings, before leaving the maker's yard. In the 838 boilers examined, 134 defects were discovered, 13 of them being dangerous. Furnaces out of shape, 6,—1 dangerous; fractures, 29,—1 dangerous; blistered plates, 7,—1 dangerous; internal corrosion 31,—2 dangerous; external ditto, 24,—3 dangerous; internal grooving, 21,—1 dangerous; external ditto, 3; blow-out apparatus out of order, 2,—both dangerous; safety-valves ditto, 2,—1 dangerous; pressure gauges ditto, 7; boilers without glass without gauges, 1,—dangerous; without feed back pressure valves, 1.

Corrosion: Internal and External:—The following facts are of interest with regard to a boiler of the ordinary Lancashire mill type, 6ft. in diameter, which was recently enrolled with this association. Prior to enrolment the owner had been assured by his engineman last Whit-week that he had examined the boiler, and that it was in a thoroughly satisfactory condition. Shortly after, however, the water leaked away through the bottom till it disappeared from the gauge glass. In consequence of this the boiler makers were sent for, when, on getting into the external brickwork flues, they found that the plates were so seriously wasted by external corrosion that they soon riddled the bottom with a hammer, the thickness proving in places not to exceed that of an old sixpenny piece. On this they set to work to repair the parts resting on one of the seatings, and the owner meanwhile called at the offices of the association and enrolled the boiler. On the inspector's making his first examination the next day, he found that the plates resting on the other side wall needed repair as much as those on which the boiler makers were already at work, when it was promptly reported to the owner that after repairs to the left hand side were completed, the boiler would then have to be treated in like manner on the right hand side, while in addition, it had been so weakened by the ravages of corrosion internally, that after the above-mentioned repairs were effected, still it would be unfit for use. Under these circumstances the owner had no option but to condemn the boiler altogether, and to sacrifice the money already laid out in precipitate repairs. It is a matter for great congratulation that the decrepit state of this boiler did not lead to a violent explosion. The danger had been imminent. Had the boiler been under competent periodical inspection, this danger would have long since been detected, and the course of the corrosion in all probability arrested, whereby the owner would not only have been saved the expense of useless repairs, but also the inconvenience of stopping his works at a moment's notice, and keeping them standing until a new boiler could be set to work. This experience does not seem to corroborate the statement in the Parliamentary report that users are best able to ascertain the condition of their boilers.

Explosions.

On the present occasion I have three explosions to report by which nine persons have been killed, and twenty-two others injured. In each case the scene of the catastrophe has been visited by officers of the association. Before entering on the consideration of the above, the particulars of three prior explosions may be given, reference to which

had to be deferred when the last report was presented. Not one of the explosions referred to in this report sprung from boilers under the inspection of this association.

AN EXPLOSION ARISING FROM MALCONSTRUCTION, SHOWING THE NECESSITY OF HAVING A CONSTRUCTIVE EXAMINATION OF EVERY BOILER BEFORE IT LEAVES THE MAKER'S WORKS.

No. 17 explosion, by which fortunately no one was either killed or injured, occurred at a chemical works during the dinner hour, at a little after one o'clock, on Saturday, May 20th. As this explosion did not appear to be of a very important character, and occurred at a considerable distance from Manchester, it was not thought worth while to despatch an officer of the association expressly to the scene of the catastrophe, but I have been favoured with the following particulars by a boiler maker residing near the spot. The boiler was of the portable internally-fired vertical class, and of somewhat peculiar construction internally. This peculiarity consists in the fact that the flames from the internal fire box, instead of passing upwards, either through the side or crown of the shell, passed downwards through a series of return flue tubes, encircling the fire box, according to the arrangement generally known by the term of Gough's Patent. The height of the boiler was 6ft.; the diameter in the outer shell 4ft. 6in., while the flue tubes, which were 21 in number, had a length of 2ft. 8in., and a diameter of 4in. The thickness of the plates in the external shell was $\frac{3}{8}$ths of an inch, and in the fire box and tube plates $\frac{7}{16}$ths of an inch, while the pressure of steam per square inch is stated to have been 35lb. The boiler was rent into six fragments. The cylindrical portion of the shell was ripped away from the remainder and separated into three pieces, rending at the vertical seams of rivets which ran from the top of the boiler to the bottom, while the bottom tube plate was rent all the way round through the line of holes at which the tubes were inserted. The crown plate of the boiler is reported to have been hurled to a distance of 150 yards, while other parts were thrown to nearly the same distance. With regard to the cause of the explosion, this boiler had a glaring defect in its construction. There were no stays whatever to tie the crown of the fire box to the crown of the shell, so that the entire pressure on the lower tube plate, which formed the bottom of the boiler and measured 4ft. 6in. in diameter. had to be carried by the ring of angle iron by which it was attached to the external shell; added to which this plate was weakened by the circle of holes cut for the tubes, which, being 21 in number and 4in. in diameter, left only an inch and a-half of metal between them, so that nearly all the strength was cut away. Through this ring of holes one of the rents, as already stated, ran, and this in all probability was the primary one, from which the others took their origin. Though not prepared to speak positively on this point, since the fragments were not examined by an officer of this association, as already explained, yet there can be no question, whether this was the primary rent or not, that the bottom tube plate was a very weak part, and that the omission of vertical stays was a grave defect. It is, however, one which my experience with boilers of this patent construction leads me to fear is not singular. The caution, therefore, cannot be too widely circulated that all parties using boilers of the type known as Gough's Patent should at once ascertain whether the crown of the fire box is suitably stayed to the crown of the shell, so as to take the strain off the bottom tube plate, and, if not, they should have the necessary stays introduced without a moment's delay. This case of defective construction is a further contradiction of the statement by the Parliamentary Committee, that steam users are best able to ascertain the condition of their boilers, while it shows the importance of having a constructive examination of every boiler before it is allowed to leave the maker's premises.

A COLLAPSE OF A FURNACE TUBE ARISING FROM WEAKNESS, WHICH MIGHT HAVE BEEN DETECTED ON COMPETENT INSPECTION.

No. 18 explosions, by which three persons were killed and one other injured, occurred at about a quarter before twelve on the evening of Monday, May 22nd, at a seed crushing mill. The following report presented to the coroner and his jury by myself will give full particulars:—

"To John Joseph Thorney, Esq., Coroner, Hull.

"Sir,—In accordance with your instructions I examined, on Wednesday last, the 31st of May, the boiler that burst with such disastrous consequences on Monday, the 22nd of May, on the premises of . . . . Also, I have had drawings made showing the general construction of the boiler and the manner in which it has rent, which will serve to elucidate the matter more fully to the jury. On examining the boiler I found that it was of the ordinary Lancashire mill type, that is to say, it had two furnace tubes running through it from end to end, in which the fires were placed. In some cases these furnace tubes are of the same diameter throughout their entire length, while in others they are reduced shortly behind the firebridge, as was the case in this instance, while there were four conical water pipes fixed in each of the flue tubes behind the furnace, so that there was one water pipe to each belt of plating. The lenght of the boiler was 22ft. 6in.; the diameter 7ft. 6in. in the shell, and about 2ft. 10in. in the larger portion of the furnace tube, and 2ft. 6in. in the smaller portion behind the firebridge, the thickness of the plates being a light $\frac{7}{16}$ths of an inch in the shell, a light $\frac{3}{8}$ths of an inch in the furnaces, and half an inch in the flat ends, while the safety-valve, which was 5in. in diameter and loaded with a ball weighing 149 lb., had a lever of such proportions as upon calculation was found to give a load of 69 lb. per square inch. The boiler failed in the left hand furnace tube, the two sides above the level of the firebars bulging inwards. This bulging was especially severe on the right hand side, and there the tube rent through sixteen consecutive holes at the ring seam of rivets uniting the second and third widths of plating, thereby making an opening of an irregular oval shape, about 2ft, 6in. long by 6in. wide at the broadest part. It was to this rent that the sudden rush of steam and hot water were due, that caused the three deaths now under investigation. The boiler, however, was not moved from its seat, but the brickwork setting was slightly dislocated. With regard to the cause of the collapse and rent just described, it was found on examination that the plates of the furnace tube were seriously attacked by corrosion, in consequence of the solvent action of the feed water, several of the indentations eating half through the metal. The plates could ill afford this deduction in strength. A thickness of barely $\frac{3}{8}$ths of an inch which these plates were originally, was too light for so high a pressure of steam as these furnaces had to carry, seeing that they were not strengthened with any flanged joints or encircling hoops. This explosion, therefore, is attributed to the weakness of the furnace tube, consequent on the wasting of the plates from the ravages of internal corrosion, coupled with the omission of any flanged seams, encircling hoops, or other equally efficient appliances for strengthening furnace tubes so as to enable them to resist collapse. It may be well, however, for me to point out in passing that there was another influence at work tending to distress the furnace tubes, and which may have contributed to the collapse, though not sufficient to produce it single handed. This contributing cause was the sedimentary character of the feed water, coupled with the fact that the attendant was in the habit of introducing tallow, say about 20 lb., every three weeks when the boiler was cleaned out. The deposit, of which there was a good deal, on being analysed by Dr. Angus Smith, was found to contain a large quantity of carbonate of lime and carbonate of magnesia, the compound being equal to 28·69 per cent. of carbonate of lime. The practice of introducing grease where the feed water contains a good deal of carbonate of lime is not advisable, as the floury deposit formed by such waters when grease is introduced is apt to lead to overheating of the plates. Several cases of serious inconvenience from this cause have come under my own observation. In those cases, however, the per centage of carbonate of lime was higher than in this, some of the sediments containing as much as 80 per cent., though one contained a little less than 40 per cent. It appears possible that this deposite may have tended to the slight overheating of the plates, whereby the already overtaxed furnace tube was further strained, and thus the disaster hastened, though I regard it only as a contributory, and not as the primary cause. It may be added that the best way to treat boilers fed with this description of feed water is to clean them out frequently, as was done in this case, and also adopt surface blowing out. Before concluding this report it may be pointed out that it is a somewhat increasingly general practice to endeavour to strengthen the furnace and flue tubes of boilers, as was the case in this instance, with water pipes rather than with encircling rings. This practice is to be regretted. The water pipes should not be introduced to the exclusion of encircling rings. The water pipes can only be placed in the flue behind the bridge; the rings encircle the furnaces over the fire where most needed. Where water pipes are adopted behind the bridge, encircling rings should not be omitted in front of the bridge, and had they been introduced in the present instance, even though the plates had been weakened by corrosion as they were in this case, there is very little reason to doubt that the explosion would have been prevented and the lives saved. I remain, Sir, yours faithfully,

(Signed)—"LAVINGTON E. FLETCHER, Chief Engineer."

The evidence given at the inquest by those cognizant with the character of the water of the neighbourhood, fully confirmed the suspicion thrown out in the report, as to its tendency to form a floury deposit. This floury deposit is due to the presence of carbonate of lime, and the following is an analysis of the water, which shows what a large quantity it contained.

	Grains per gallon.
Carbonate of lime, with traces of nitrate of lime ...	17.20
Salts of magnesia, sulphate and carbonate	1.30
Salts of alkalies, principally chloride of sodium ...	1.90
Silica	0.60
Combustible (organic) matter	0.60
Total per gallon	21.60

It is therefore of importance that all the boilers fed with well water in the vicinity in which this explosion occurred, should be blown out frequently, not only from the bottom but also from the surface of the water, in addition to being laid off and cleaned every few weeks, while the introduction of grease should be studiously avoided. As this fine floury deposit is apt to a great extent to float away when the boiler is blown out, and thus, in some measure to escape detection, it is well in order to be assured of the fact where its presence is suspected, to allow the boiler to cool down and the deposit to settle before emptying. Detailed reference to the action of these fine floury deposits, with chemical analyses of various waters, will be found in the association's printed monthly report for May, 1869. The fact came out at the inquest that the boiler from which this explosion sprung, as well as the other boilers of this firm, had for some years been enrolled with an Insurance Company, though the owner stated he had dropped the insurance some few months before the explosion, regarding the expense incurred as unnecessary. Several reports by the company to the owner, on the condition of the boiler in question while it was insured, were handed in, all of which stated that the boiler was in good condition, or, in safe working order, not one pointing out the dangerous wasting of the plate from corrosion, though that wasting must have been in operation for a considerable time, while no mention was made of the existence of the fine floury deposit formed by the feed water. Had the weakness of the furnace tube been called attention to, the explosion might have been prevented. The jury returned a verdict of accidental death caused by the explosion of the boiler, entailed by one of the plates being corroded, adding that they did not attach any blame to the owner or the attendant who had been killed, but recommended the adoption of periodical inspection in future.

An Explosion arising from a Weak Manhole Cover.

No. 19 explosion, by which one person was killed, occurred at a little before midnight on Wednesday, May 24th, at a paper mill. The boiler in this instance was not used as a generator, but for steaming rags, there being no fire placed either inside it or outside it, the heat being applied by means of a steam pipe connected to it. Such vessels are technically termed rag boilers. It was of cylindrical egg-ended construction, and carried on a couple of trunnions very much like the oscillating cylinder of a steam engine. On these trunnions the boiler revolved, the steam being admitted to the interior, and the water drained off, through them. The length of the boiler was as nearly as may be 12ft., its diameter 6ft., and the thickness of plates about $\frac{6}{16}$ths of an inch, while the pressure in the steam boiler to which it was connected was 50 lb. on the square inch. At one of the hemispherical ends of the boiler there was a large manhole, through which the rags were put inside the boiler to be steamed, and taken out when done. The explosion arose from the cover of this manhole being blown off. The cause of this fracture was simply the weakness of the structure. The cover was only secured by four bolts an inch in diameter, though the diameter of the circle on which those bolts were placed was as much as 28in. Manhole covers of first-class boilers, though some six inches smaller in diameter than this, have ten bolts, so that it will be seen the number in this case was thoroughly inadequate. The cover also was light, being only an inch and a sixteenth thick, though of so large a diameter, and unassisted by any strengthening ribs. At the inquest no useful information was gained. The jury, several of whom are reported to have been practical engineers, returned a verdict of accidental death, while the coroner spoke of the cause of the explosion as remaining inexplicable from the evidence. It is certainly time that such inquiries should be amended.

"Tabular Statement of Explosions from May 27th, 1871, to July 21st, 1871, inclusive.

Progressive No. for 1871.	Date.	General Description of Boiler.	Persons Injured.	Persons Killed.	Total.
20	June 17	Single-flued, or 'Cornish.' Internally-fired	1	1	2
21	June 28	Single-flued. Externally-fired	8	20	28
22	July 11	Single-flued, or 'Cornish.' Internally-fired	0	1	1
		Total	9	22	31

Another Life sacrificed from the Neglect of Encircling Hoops, or other Strengthening Appliances for Preventing Collapse.

No. 20 explosion, by which one man was killed and another injured, occurred between seven and eight o'clock on the morning of Saturday, June 17th, at an iron works. The boiler was of the plain Cornish class, having a single flue running through it, in which the fire was placed. Its length was 28ft., its diameter in the shell 6ft., and in the furnace tube 3ft. 1in., as nearly as could be ascertained after the explosion, the thickness of the plates being $\frac{3}{8}$ths of an inch in the shell, and $\frac{3}{8}$ths of an inch bare in the furnace tube, while the pressure at which the safety-valve blew off appeared to be about 40 lb. to 45 lb. on the square inch, though it would have amounted to 55 lb. on the square inch with the weight at the end of the lever. The boiler gave way in the furnace tube the tube collapsing laterally on the right hand side from one end of the boiler to the other, with the exception of about four feet at the firing end. This violent distortion of the tube led to its rending at three of the ring seams of rivets, which thus formed three openings, through which the steam and hot water rushed out in a torrent, when the boiler was lifted from its seat, and hurled forwards to a distance of 195ft. The cause of the explosion is one that has been alluded to with monotonous repetition on previous occasions, viz., the weakness of the furnace tube consequent on the neglect of flanged seams or encircling hoops, whether of T iron, bridge rail, or other approved section, or of any other efficient means for resisting collapse. Had any one of these simple precautions been adopted the collapse would have been prevented. It may be pointed out in passing that it is stated the boiler had been tested by hydraulic pressure to about 80 lb. per square inch a few months before the explosion, and that it appears this test was applied without any one's passing through the tube at the time in order to take gaugings, and ascertain whether there was any movement or not. Had this been done it is more than probable that some indications of the weakness of the furnace tube would have been detected. Blind hydraulic tests are useless. Indeed in many cases they may be absolutely dangerous, inasmuch as they may strain a boiler and distort its shape without its being known. At the inquest the jury brought in the following verdict, which is much clearer and more to the point than the verdicts on such occasions usually are:—The jury find that the deceased was killed by the collapse of the flue which occurred on the 17th of June, and while they are of opinion there is nothing to show gross or culpable negligence on the part of the owners, yet they consider there was not sufficient precaution used in the purchase of the boiler, as the scientific evidence all tends to show that it was not strong enough for the work to which it was put. It is reported that the owners of the works have made the widow of the poor man who was killed, an allowance of ten shillings a week for ten years, which it will be seen involves an outlay of upwards of £250. This, however generous, does not restore the life that has been lost, while a system of compulsory inspection, which would have cost the owners but about £2 per boiler per annum, would not only have prevented the explosion and its consequent loss of life, but also have saved the outlay of the £250, as well as the loss of the boiler, and the interruption of the regular business of the works.

(To be Continued.)

INSTITUTION OF MECHANICAL ENGINEERS.

Meeting at Middlesbrough.

ON THE MANUFACTURE OF HEMATITE IRON.

By Mr. William Crossley.

The furnaces of the hematite district are much the same as those at work at Cleveland, but the appliances for working them are not usually quite so good. The Barrow furnaces, which are a fair type ,are about 55ft. high and 16ft. diameter at the boshes, having a capacity of about 9,000 to 10,000 cubic feet. The Askam furnaces are 67ft. high and 19ft. wide at the boshes, tapering to 18ft. below the gas outlet, and have a capacity of 13,100 cubic feet. Larger furnaces do not appear to have been successful. The Askam furnaces, of 67ft. height, did not work well for some time, and the cause is attributable to the smallness of the charging bells in proportion to the width of the furnaces, and consequently larger bells were substituted. The bells first used were only 7ft. 6in. in diameter, but the present are 12ft. 6in in. diameter, and are believed to be the largest of any in use for hematite furnaces. The furnaces work well, and produce from 400 to 450 tons of iron, a large proportion being for Bessemer converters. The dimensions of the furnaces are as follows:—Height, 67ft.; diameter of boshes, 19ft.; diameter at throat, 18ft.; diameter at hearth, 7ft.; heating surface, 5,500 square feet; number of tuyeres 6; area of blast inlet, 75 square inches; pressure of blast at engine, 3lb.; pressure of blast at tuyeres $2\frac{3}{4}$lbs.; area of gas outlet, 18 square feet; diameter of charging bell, 12ft. 6in.; make of iron

per furnace, 400 to 460 tons per week. For taking off the blast furnace gas the bell and hopper arrangement adopted in the Cleveland district has not been found to answer so well in the hematite district. The author did not believe in the objections to the system, viz., that it operated prejudicially upon the qnality of the iron, and that it threw a heavier back-pressnre on the furnaces, and thus interfered with their regular working. Butin his opinion the sole explanation is to be found in an improper distribution of the materials, owing to the bell not being suitably proportioned to the size of the furnace throat. The author then described a furnace now building at Askam, and being 75ft. high and 23ft. diameter at the boshes. He then described the ones used in the manufactnre of hematite iron. The best Whitehaven ores are richer in iron than the best Furness ores. In Furness the poorer blast ores usually contain abont 45 per cent., of metallic iron, while the better qualities run up to 57, and in some cases 60 per cent. In Whitehaven the poorer ores contain about 50 per cent. of metallic iron, and the best run up to 60 or 65 per cent., but the average percentage of iron in the ores used in both districts is probably between 57 and 60 per cent. The ore nsed at Askam has the composition showu in

Table No. 1.—Askam Ore.

	Per cent.
Peroxide of iron	83·00
Silica	15·50
Carbonate of lime	trace
Moisture	1·50
	100·00
Metallic iron	58·10

The principal impnrity is silica, and, unlike Cleveland and most other ores, this ore does not contain any alumina. Aluminous ores are, therefore, mixed with it, for the purpose of producing a better slag. The addition of aluminous ores also gives the means of controlling in some measure the percentage of silica in the iron.

The aluminous ores are mostly Irish, and are fairly represented in

Table No. 2.

	Lithomarge.	Red aluminous Ores.	Black nodular.
Silica	30·70	11·25	6·00
Alumina	27·05	35·61	20·37
Titanic acid	trace	trace	·75
Peroxide of iron	25·05	34·65	71·63
Protoxide	trace	none	·68
Magnesia and lime	1·11	trace	trace
Water of combination	15·85	16·30	1·15
Metallic iron	17·35	23·25	50·14

The lithomarge has been longest in use, and is preferred at some works; bnt the writer believes the other two varieties to be better for most purposes, because the percentage of silica in the lithomarge is so high in proportion to the alumina that a very large qnantity must be used to produce any appreciable differeuce in the composition of the slag, and in the smelting of the materials a still higher objection to the lithomarge is the quantity of water it contains, which must have a very injurious effect in cooling the escaping gases of the furnace, and thus increasing the consumption of fuel. The red aluminous ore has also the disadvantage of containing usually about 15 or 16 per cent. of water. The hematite being found in a limestone formation and worked in the district, there is a plentiful supply of good and cheap limestone. That used at Askam has the composition shown as follows:—

Table No. 3.—Stainton Limestone.

	Per cent.
Carbonate of lime	95·00
Carbonate of magnesia	4·20
Oxide of iron and alumina	0·30
Silica	0·50
	100·00

The coke is almost entirely obtained from the Durham coal-field, and is usually of the best quality. The average composition is as follows:—

Table No. 4.

	Per cent.
Sulphur	·70
Ash	5·00
Moisture and loss	·92
Carbon	93·38
	100·00

In working so difficult a material as the hematite ore, the first and most important point to be attended to is the proper distribution of the materials in the furnace, It is also necessary to prevent the charging of the ore in too large pieces, otherwise it is fonnd excessively difficult, owing to the compact nature of the ore, to ensure its perfect rednction before it reaches the part of the furnace at which it is melted. A fnrther difficulty is met within keeping the tnyere breasts good, as any "fretting" at these places leads to the necessity for changing the tuyeres, and consequently occasions irregularity of working. To obviate this a somewhat different construction of tnyere has been adopted. It consists of a close double coil of water pipe iu the centre of the onter coil, 14in. in diameter, and of the depth of the tuyere breast; the tuyere itself is packed with clay. In the event of its leaking it can then easily be removed by taking out the clay, and another tuyere can be substituted, the whole process of changing the tuyere only occupying from ten to fifteen minutes.

The result of the working of the Askam No. 2 furnace, of 67ft. height, 19ft. in diameter, and 13,100 cubic feet capacity, has been found to be a consumption of $22\frac{3}{4}$ cwt. of coke per ton of iron made, when working Bessemer iron and using the Askam ore, mixed with about 10 per cent. of black nodular ironstone and fluxed with $9\frac{1}{2}$ cwt. of limestone per ton of iron made. The average temperature of the blast, during a considerable period of observation, was 934 deg. Fah. and that of the escaping gases at the fnrnace top about 712 deg. Fah. The weight of the escaping gases is 120 cwt. per ton of iron made, and the quantity of heat carried off by them when escaping at the temperature of 733 deg. Fah, amouuts consequently to 21,920 cwt. Fah. units, one such unit being the quantity of heat required to raise 1 cwt. of water through 1 deg. of temperature Fah. The weight of blast supplied to the furnace is 92 cwt. which at the temperature of 968 deg. Fah., introduces into the furnace 20,760 units of heat; this is in the proportion of about 95 per cent. of the heat that is carried off the escaping gases. The composition of the Bessemer and forge iron made in the fnrnace and also of the slag is given in the accompanying tables.

Table No. 5.—Askam Hematite Pig Iron.

	No. 1 B.	No. 3 B.	No. 4 F.
Carbon graphite	3·928	3·377	2·719
Carbon combined	·109	·469	1·222
Silicon	2·640	2·424	1·608
Aluminium	trace	trace	trace
Manganese	·093	·021	·021
Calcium	·021	·050	·074
Magnesium	trace	trace	trace
Sulphur	·004	·004	·031
Phosphorous	·014	·010	·016
Iron	93·191	93·905	94·309
	100·000	100·000	100·000

Table No. 6.—Slag from No. 2 Furnace Askam.

	Per cent.
Silica	38·00
Alumina	10·00
Lime	42·19
Magnesia	1·65
Sulphide of calcium	2·45
Protoxide of iron	2·08
Potash	1·60
Protoxide of manganese	trace
Soda and loss	2·03
	100·00

The quantity of coke used—$22\frac{3}{4}$ cwt. per ton of iron made— may seem large, but it is to be remembered that this quantity is the resnlt obtained in making Bessemer iron, which requires a specially high intensity of heat. The same furnace, making forge iron, would work well with about 2 cwt. less. Another point worthy of attention is the small percentage of carbonic acid in the escaping gas, which seems to indicate, first, either that the ore is not so easily reducible as has been supposed, or secondly, that owing to its compact nature, or else its bad mechanical condition, the rednciug gases do not ascend with the regularity which is obtained in a Cleveland furnace, and, therefore, do not effect that amount of reduction in the higher and cooler part of the furnace which is favourable to the production of carbonic acid at such a temperature as to prevent its own subsequent rednction to carbonic

oxide; and the very high temperature of the escaping gases from the hematite furnaces appears to the writer to support such a conclusion. It is also evident from the examination of these results that if it be possible in Cleveland to get the gases evolved in the furnace at as low a temperature at 312 deg. Fah. (as at the very large furnaces at Ferry Hill), and containing as much as 15 per cent. of carbonic acid, then it follows that for the purpose of making Bessemer iron the maximum size of furnace for working with the greatest economy of fuel has not yet been reached in the hematite district. On the other hand, it must also be remembered that the hematite ore is a material which is not so easily worked as Cleveland iron-stone, and does not admit of the free passage of the ascending gases, which is so essential to the good working of a furnace. In fact, there are other questions of working to be considered in the manufacture of Bessemer iron, which are as important as economy in fuel, if not more so; and although the 75ft. furnace now building at Askam is not the first hematite furnace of that height which has been built, and previous steps taken in the direction of increased height have not answered the expectations raised respecting them, the writer expresses his belief that there are sufficient grounds for feeling sanguine as to the success of the present attempt.

ON THE GENERAL GEOLOGICAL FEATURES OF THE CLEVELAND DISTRICT.

By Mr. John Jones.

The author stated that during the last twenty years the Cleveland Hills have risen into national importance as a mining centre, and from them is raised ore sufficient to produce one-third of the manufactured iron in Great Britain. Previous to 1850 it was known that ironstone existed, but it was not considered valuable enough for working, till the supply of ironstone from the coal measures of Durham had failed. He mentioned that the late Mr. Vaughan discovered the "main seam" of Cleveland in the face of the Eston Hills, and soon afterwards the erection of blast furnaces on the banks of the Tees was commenced. From that time to this the industrial activity of the district has gone on increasing steadily. After defining the part included in Cleveland, the writer said that the lowest geological formation is the new red sandstone, and that the course of the Tees from near Darlington to the sea lies through the triassic series. There is a line of fault between Middlesbrough and Seaton. It has been proved that the Keuper marls of North Yorkshire contain deposits of salt rock. Messrs. Bolckow, Vaughan, and Co. had come upon a mass upwards of 100ft. thick, when boring for water at their Middlesbrough works. It was thought that this could be pumped up in the form of brine, but as this did not succeed a couple of shafts are now being sunk. The top beds of the Keuper, near Lackenby and Eston stations contain gypsum, which is being extracted for commercial purposes. A good deal of iron is found in the triassic series. Irregular bands occur at intervals. Nodular masses are also found, and the whole formation is tinged a more or less deep shade of brown from the oxide of iron dispersed through it. It is in the top portion of this series that the main seam of Cleveland ironstone is situated, and from which the bulk of the stone now being smelted in this district is derived. Mineralogically, the stone is an impure carbonate of protoxide of iron, containing from 27 to 33 per cent. of metallic iron. This seam crops out along the northern slope of the Eston Hills. It there attains its maximum development, being in places nearly 14ft. in thickness, and containing from 32 to 33 per cent. of iron. Proceeding eastwards at Upleatham, the stone is found cropping out also, and there it is from 11ft. to 12ft. in thickness. At Hob Hill, near Saltburn, there is a small patch of ironstone. The ironstone bed may be traced along the coast in various places, but beyond Skinningrove it begins to split up, and the percentage of iron is not so high. South-west of Guisbrough the seam is much thinner, and at present the mines at Hutton Low Cross and Cod Hill are not worked. At Belmont, and other places, south and east of Guisbrough, the stone improves in thickness and quantity, and is extensively worked. The principal mines in Cleveland are situated in the Eston Hills (which with Ormesby and Normanby, cover an area of from three to four square miles), and in a tract of country extending about six miles south-east from Upleatham and Guisbrough, and having an average breadth of about four miles. Over this area the ironstone has been for the most part proved, and large royalties are being opened out along the southern margin of the district under notice. The best stone of Cleveland is now known to cover from twenty-seven to thirty square miles, and at the present rate of extraction, it is calculated that there is in this area alone sufficient store to last the whole of the existing blast furnaces nearly 100 years to smelt. Several analyses of ores were given, in which it was shown that the Eston stone is the richest, containing 33·62 per cent. of metallic iron, whilst the Upleatham had 31·97, and the Normanby 31·42 per cent. It is an undoubted fact, that there are many square miles of ironstone lying beyond the present active mining field which will eventually come into the market, but not to any large extent until the portions nearest the coal-field are exhausted. Near the top of the upper lias, another seam of ironstone, called the "Top Seam" of Cleveland, exists. This is a very variable seam both in extent and richness, being in some parts extremely thin, and in others it opens out into large dimensions. In Cleveland proper it is not worked, but further south it is being developed. The character of the stone, too, is not uniform. It is for the most part an impure oxide of iron, and yields in some places 40 per cent, metallic iron. At Rosedale and Glaisdale, both beyond the limits of Cleveland, it is being largely extracted. At the former place, underlying the top seam, a large deposit of magnetic ores are found, but these are being rapidly exhausted. The deposit appears to be of a purely local character. There are not many faults to be found in the ironstone measures, though the undulations of strata cause the main seam to be found at very different levels. The main seam attains its maximum development towards the north, where also it yields the highest percentage of iron. Passing towards the south, there is a gradual thinning out of the seam, until at length shale partings come in, splitting up the ironstone into thin bands, of which not more than two are workable. The percentage of metallic iron also gradually falls until the stone becomes too lean to admit of its being used for smelting purposes. Indeed, it may be asserted broadly that at the present time a stone containing 24 per cent. of metallic iron may be regarded as of no practical value, and that each unit of metallic iron above this point has a value of about 6d. per ton. The higher members of the oolitic series contain a number of unimportant seams of ironstone, though in the neighbourhood of Castle Howard, somewhat extensive deposits of iron ore exist, but they are not sufficiently uniform in quality, or rich in metallic iron, to render them available for smelting purposes on a large scale. It would seem that the lias and oolitic strata of North Yorkshire contain immense quantities of iron ore in the form of impure oxides or carbonates. The richest tract, however, is in North Cleveland, where an ironstone averaging from 30 to 31 per cent of metallic iron is now being raised—to the extent of from five to six millions of tons annum—and can be sold, after allowing a fair margin for profit, at from 3s. 6d. to 4s. per ton at the mines. The mines in this part of the district are within a few miles of the principal smelting works, and are also comparatively near to the Durham coal-field. It is impossible, therefore, for many of the thinner beds of ironstone further south to be brought into successful competition with the North Cleveland mines, and large quantities of really valuable ironstone will have to remain unworked until the richer districts become partly exhausted. Where the ironstone crops out along the escarpments of the lias hills, it is worked by means of day-levels, but in other cases shafts have to be sunk in the ordinary manner; but these do not, as a rule, exceed 100 fathoms in depth, whilst some are very shallow. The stone is worked upon the board and pillar system. After describing this method the author stated that the cost of haulage is very trifling and that the ventilation of the mines does not present much difficulty, as no explosive gases are met with, and the excavations are mostly very lofty and extensive, so that a good current of air can be readily made to pass through. At the Liverton mines, east of Saltburn a combustible gas has been met with which is now being utilised for illuminating purposes. The stone is there impregnated with bituminous matter. The author remarked that it has been proved that in Cleveland proper no coal measures at a workable distance from the surface exist. He then gave a short description of the Durham coal-field, from which at the present time so great a part of the coal and coke used in the smelting of iron in the district is obtained. He stated that the south-western portion of the field yields several excellent seams of coal which are well suited for the productions of coke of the best quality. The hardness of this material makes it adapted to bear a heavy burden in the blast furnace. The limestone used in the furnaces is obtained from Stanhope, Merrybent, and Forcett. Some had been got from the neighbourhood of Pickering, near York, and magnesian limestone from near Ferry Hill. The Cleveland district, the author showed, presented several features not usually met with in iron-making localities. The greater portion of the blast furnaces are situated near to Middlesbrough and Stockton, on each side of the Tees. They stand upon a geological formation that does not yield any of the minerals used in the blast furnaces. The ironstone is brought a distance of from three to twenty miles; the coal and coke are brought from the South Durham coal-field, and the limestone is brought distances varying from twenty to forty miles. It is found, however, more convenient and economical to fix the works near to the river, as this affords greater facilities for getting away the manufactured article.

ON A SIMPLE CONSTRUCTION OF STEAM ENGINE GOVERNOR, HAVING A CLOSE APPROXIMATION TO PERFECT ACTION.

By Mr. Jeremiah Head.

The object of this paper was to show that, while the ordinary Watt governor, as at present in use, allows a serious change of speed before

FIG. 1.

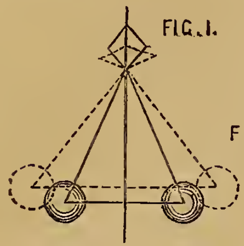
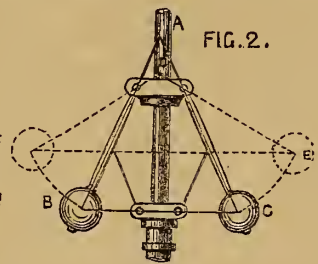


FIG. 2.



it effects the required regulation in the supply of steam to the engine, yet it may, without any material increase of complexity or expense, be

FIG. 3.

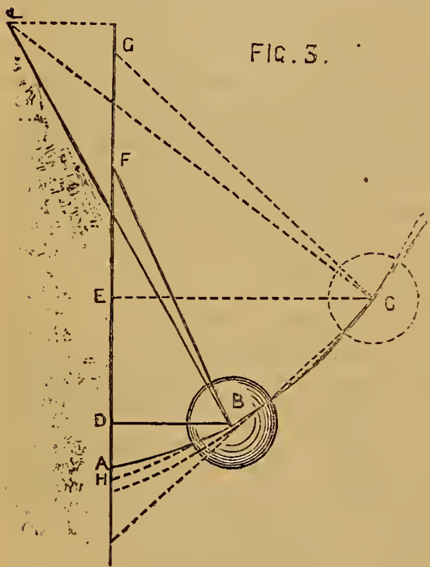


FIG. 4.

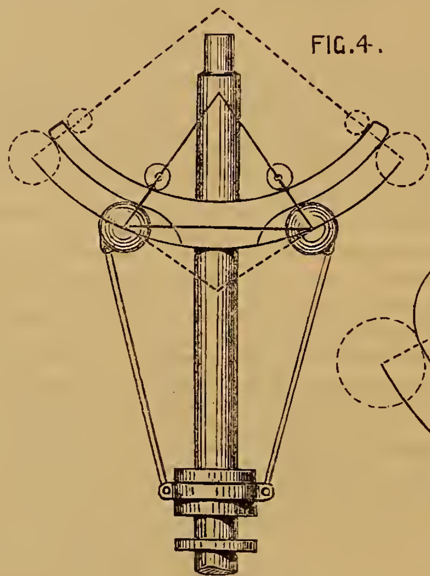
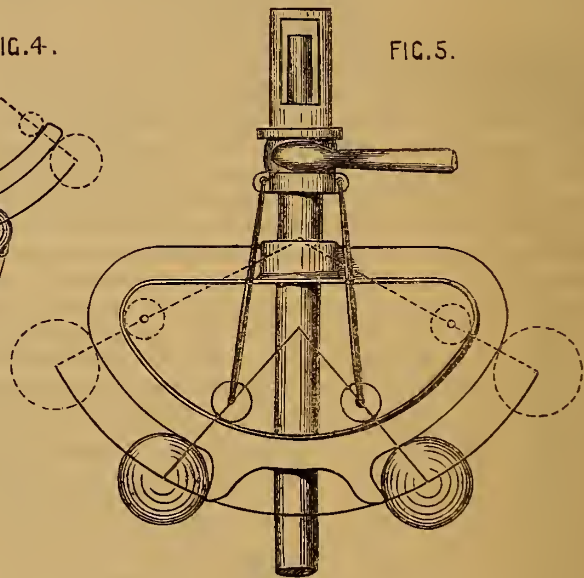
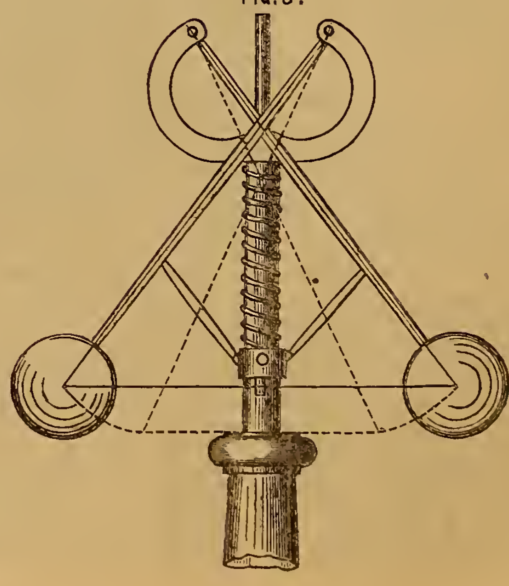


FIG. 5.



so modified in construction as to approach very nearly to the standard of theoretical perfection. The author examined the mode of action of the conical governor, and compared it with that of the parabolic governor. He then went on to say that in the form of governor made by Watt the actual extent of variation of speed was reduced to a very small amount. Fig. 1 is a diagram of the original governor preserved at South Kensington. By choosing a height of cone which corresponded with a slow speed, and making the angle of tho arms with axis small at their lower position, and limiting the change of anglo to a minimum, and by the method of actuating the sliding piece at the top, he secured a sufficient rise and fall of latter with an extremely small change of height in tho described cone. Fig. 4 represents the first parabolic governor introduced into this country at tho Exhibition of 1851 by an exhibitor from Vienna. Tho balls were suspended by links from rollers, and tho arms were bent so as to causo tho centres of tho balls to describe a parabola. The writer had applied a governor of this kind to some engines at Darlington a few years afterwards, and he found it necessary to control the perpetnally running up and down by attaching to the sliding piece an air cylinder, as shown in Fig. 5. The governor then became perfectly successful. There are, however, some disadvantages connected with the parabolic governor: it is somewhat complicated and costly, and the surfaces of the rollers and the paths npon which they travel are liable to wear into inequalities of level. These considerations suggested the idea of constructing a simpler governor by sacrificing a small portion of the perfection obtained by adhering rigidly to the true parabola. Referring to the dotted line in Fig. 3, although no arc of a circle can exactly coincide with a portion of a parabola, yet it may approximate very nearly. If, then, the ball is hung from L, the centre from which such a circular arc is described, a governor will be obtained that is nearly parabolic, and with all the simplicity of the ordinary governor. It will be seen that the centres of suspension are situated each on the side of the vertical spindle opposite to the suspended ball, the arms being crossed. The mode of laying down this approximate parabolic governor is as follows:—The lowest position of the ball B is first fixed according to convenience, and the height of the cone D F is determined according to the number of revolutions intended. The line B H is then drawn at right angles to B F, and the bisection D H at A gives the apex of the parabolic curve. The total rise D E of the ball is then fixed at the amount considered desirable, and tho proportion of E C to D B is made the same as that of $\sqrt{\text{E A}}$ to $\sqrt{\text{D A}}$. A point C is then found in the parabolic curve, as the ordinate E C of a parabola is proportionate to the square root of the corresponding abscissa E A; and in a similar way any number of other intermediate points are found. It only remains to find by trial a centre L, from which an arc may be drawn coinciding as nearly as possible with that portion of the parabola between B and C. In order to ascertain the number of revolutions corresponding to any height of cone from 6in. to 36in., calculations are made from the data that the number of revolutions is inversely proportionate to the square root of the height of the cone, and that when the latter is 39·1393in., or the length of tho seconds' pendulum, the time of revolution is equal to a double oscillation thereof, or two seconds. Fig. 6 represents a governor on tho plan at present in use at the Newport Rolling Mills. Here the air cylinder is done away with, and a spiral spring placed upon the spindle. There are ten

FIG. 6.



of these governors at work at the Newport Mills. The error in action of the ordinary governor becomes increased where the arms are hung from two separate points of suspension, away from the spindle, and each on the same side as its suspended ball, as shown in Fig. 2. Then the fault of variability in height of the cone becomes aggravated, the apex being actually lowered, instead of remaining stationary, as the balls rise, the variation of speed with snch a governor is proportionately increased, and in extreme cases hardly any benefit can be derived. In the governor shown in Fig. 2 the balls would begin to rise at twenty-eight and a-half revolutions, and it would require forty-six to reach the position shown in dotted lines. The cone A B C, curtailed at both ends, becomes at last that represented by D E F. The extreme variation of the engines would amount to forty-seven per cent. of its mean speed.

THE BRITISH ASSOCIATION.

INAUGURAL ADDRESS.

By Sir William Thomson.

For the third time of its forty years' history the British Association is assembled in the metropolis of Scotland. The origin of the association is connected with Edinburgh in undying memory through the honoured names of Robinson, Brewster, Forbes, and Johnston. Of the little band of four pilgrims from Scotland to York, not one now survives. Of the seven first Associates one more has gone over to the majority since the Association last met. Vernon Harcourt is no longer with us; but his influence remains a beneficent, and surely, therefore, never-dying, influence. He was a geologist and a chemist, a large-hearted lover of science, and an unwearied worker for its advancement. Brewster was the founder of the British Association; Vernon Harcourt was its law-giver. His code remains to this day the law of the Association. On the 11th day of May last Sir John Herschel died, in the 80th year of his age. The name of Herschel is a household word throughout Great Britain and Ireland—yes, and throughout the whole civilised world. We of this generation have, from our lessons of childhood npwards, learned to see in Herschel, father and son, a *prœsidium et dulce decus* of the precious treasure of British scientific fame. When geography, astronomy, and the use of the globes were still taught, even to poor children, as a pleasant and profitable sequel to reading, writing, and arithmetic, which of us did not revere the great telescope of Sir William Herschel (one of the hundred wonders of the world), and learn with delight, directly or indirectly, from the charming pages of Sir John Herschel's book, about the sun and his spots, and the fiery tornadoes sweeping over his surface, and about the planets, and Jupiter's belts and Saturn's rings, and the fixed stars with their proper motions, and the double stars and coloured stars, and the nebulæ discovered by the great telescope? Of Sir John Herschel it may indeed be said, "Nil tetigit quod non ornavit." A monument to Faraday and a monument to Herschel Britain must have. The nation will not be satisfied with anything, however splendid, done by private subscription. A national monument, the more humble in point of expense the better, is required to satisfy that honourable pride with which a high-spirited nation cherishes the memory of its great men. But for the glory of a Faraday or the glory of a Herschel is a monument wanted? No.

> "What needs my Shakespeare for his honoured bones
> The labour of an age in piled stones?
> Or that his hallowed reliques should be hid
> Under a stary-pointing pyramid?
> Dear son of memory, great heir of fame,
> What need'st thou such weak witness of thy name!
> Thou, in our wonder and astonishment,
> Hast built thyself a livelong monument."

Coming next to the work of the Association, Sir William noticed that though the splendid donation by Mr. Gassiot of £10,000 the regular continuance of the observations by self-recording instruments at Kew of terrestrial magnetism and meteorology was permanently secured without the assistance of the Association. Still, however he had to regret the absence of means for public scientific instruction. "The physical laboratories which have grown up in the Universities of Glasgow and Edinburgh, and in Owens College, Manchester, showed the want of Colleges of Research, while going but infinitesimally towards supplying it. The whole of Andrews' splendid work in Queen's College, Belfast, had been done under great difficulties and disadvantages, and at great personal sacrifices; aud up to the present time there was not a student's physical laboratory in any one of the Queen's Colleges in Ireland—a want which surely ought not to remain unsupplied. Each of these institutions (the four Scotch Universities, the three Queen's Colleges, and Owens College, Manchester) required two professors of Natural Philosophy—one to be responsible for the teaching, the other for the advancement of science by experiments. The University of Oxford had already established a physicial laboratory. The munificence of its Chancellor was about to supply the University of Cambridge with a splendid laboratory, to be constructed under the eye of Professor Clerk Maxwell." In passing to recent advances in science, the President said: "I shall simply choose some of those that seem to me most notable. To a non-scientific imagination acourate and minute measurement seems a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient long-continued labour in the minute sifting of numerical resnlts. The popular idea of Newton's grandest discovery is that the theory of gravitation flashed into his mind, and so the discovery was made. It was by a long train of mathematical calculation, founded on results accumulated through prodigious toil of practical astronomers, that Newton first demonstrated the forces urging the planets towards the sun, determined the magnitude of those forces, and discovered that a force following the same law of variation with distance urges the moon towards the earth. Then first, we may suppose, came to him the idea of the university of gravitation; but when he attempted to compare the magnitude of the force on the moon with the magnitude of the force of gravitation of a heavy body of equal mass of the earth's surface, he did not find the agreement which the law he was discovering required. Not for years after would he publish his disoovery. It is recounted that, being present at a meeting of the Royal Society, he heard a paper read describing geodesic measurement by Picard which led to a serious correction of the previously accepted estimate of the earth's radius. This was what Newton required. He went home with the result, and commenced his calculations, but felt so much agitated that he handed over the arithmetical work to a friend: then—and not when sitting in a garden he saw an apple fall—did he asertain that gravitation keeps the moon in her orbit. Faraday's discovery of specific inductive capacity, which inaugurated the new philosophy, tending to discard action at a distance, was the result of minute and accurate measurement of electric forces. Joule's discovery of thermo-dynamic law through the regions of electro-chemistry, electro-magnetism, and elasticity of gases was based on a delicacy of thermometry which seemed simply impossible to some of the most distinguised chemists of the day. Andrews' discovery of the continuity between the gaseous and liquid states was worked out by many years of labourions and minute measurement of phenomena scarcely sensible to the naked eye. The origin of exact science in terrestrial magnetism is traceable to Gauss's invention of methods of finding the magnetic intensity in absolnte measure. To Kirchhoff belongs, I believe, solely the great credit of having first actually sought for and found other metals than sodium in the sun by the method of spectrum analysis. His publication of October, 1859, inaugurated the practice of solar and stellar chemistry, and gave spectrum analysis an impulse to which in a great measure is due its splendid successful cultivation by the labours of many able investigators within the last ten years. To the prodigious and wearing toil of Kirchhoff himself, and of Angström, we owe large-scale maps of the solar spectrum, incomparably superior in minuteness and accuracy of delineation to anything ever attempted previously. These maps now constitute the standards of reference for all workers in the field. The scientific value of the meetings of the British Association is well illustrated by the fact that it was through conversation with Plücker at the Newcastle meeting that Lockyer was first led into the investigation of the effects of varied pressure on the quality of the light emitted by glowing gas which he and Frankland have prosecuted with such admirable success. Scientific wealth tends to accumulation according to the law of compound interest. Thus Frankland, led, from observing the want of brightness of a candle burning in a tent on the snmmit of Mont Blanc, to scrutinise Davy's theory of flame, discovered that brightness without incandescent solid particles is given to a purely gaseous flame augumented pressure, and that a dense ignited gas gives a spectrum comparable with that of the light from an incandescent solid or liquid. Lockyer joined him, and the two found that every incandescent substance gives a continuous spectrum—that an incandescent gas under varied pressure gives bright bars across the continuous spectrum, some of which, from the sharp, hard and fast lines observed where the gas is in a state of extreme attenuation, broaden out on each side into nebnlons bands as the density is increased, and are ultimately lost in the continuous spectrum when the condensation is pushed on till the gas becomes a fluid no longer to be called gaseous. More recently they have examined the influence of temperature, and have obtained results which seem to show that a highly attenuated gas, which at a high temperature gives several bright lines, gives a smaller and smaller number of lines, of sufficient bright-

ness to be visible, when the temperature is lowered, the density being kept unchanged. I cannot refrain here from remarking how admirably this beautiful investigation harmonises with Andrews' great discovery of continuity between the gaseous and liquid states. Such things make the life-blood of science,. In contemplating them we feel as if led out from narrow waters of scholastic dogma to a refreshing excursion on the broad and deep ocean of truth, where we learn from the wonders we see that there are endlessly more and more glorious wonders still unseen. While these great investigations of properties of matter were going on, naturalists were not idle with the newly recognised power of the spectroscope at their service. Chemists soon followed the example of Bunsen in discovering new metals in terrestrial matter by the old blow-pipe and prism test of Fox Talbot, and Herschel. Biologists applied spectrum analysis to animal and vegetable chemistry, and to sanitary investigations It is in astronomy that spectroscopic research has been carried on with the greatest activity, and been most richly rewarded with results. The chemist and the astronomer have joined their forces. An astronomical observatory has now appended to it a stock of reagents such has hitherto was only to be found in the chemical laboratory. A devoted corps of all nations, whose motto might well be *ubique*, have directed their artillery to every region of the universe. The sun, the spots on his surface, the corona and the red and yellow prominences seen round him during total eclipses, the moon, the planets, comets, auroras, nebulæ, white stars, yellow stars, red stars, variable and temporary stars, each tested by the prism, was compelled to show its distinguishing prismatic colours. Rarely before in the history of science has enthusiastic perseverance directed by penetrative genius produced within ten years so brilliant a succession of discoveries. It is not merely the chemistry of sun and stars, as first suggested, that is subjected to analysis by the spectroscope. Their whole laws of being are now subjects of investigation; and already we have glimpses of their evolutional history through the stupendous power of this most subtle and delicate test. We only had solar and stellar chemistry; we have now solar and stellar physiology. I believe I may say, on the present occasion, when preparation must again be made to utilise a total eclipse of the sun, that the British Association confidently trusts to our Government exercising the same wise liberality as heretofore in the interests of science. The old nebular hypothesis supposes the solar system aud other similar systems through the universe, which we see at a distance as stars, to have originated in the condensation of fiery nebulous matter. This hypothesis was invented before the discovery of thermodynamics, or the nebulæ would not have been supposed to be fiery; and the idea seems never to have occurred to any of its inventors or early supporters that the matter, the condensation of which they supposed to constitute the sun and stars, could have been other than fiery in the beginning. Mayer first suggested thst the heat of the sun may be due to gravitation; but he supposed meteors falling in to keep always generating the heat which is radiated year by year from the sun. Helmholtz, on the other hand, adopting the nebular hypothesis, showed in 1854 that it was not necessary to suppose the nebulous matter to have been originally fiery, but that mutual gravitation between its parts may have generated the heat to which the present high temperature of the sun is due. Further, he made the important observations that the potential energy of gravitation in the sun is even now far from exhausted; but that with further and further shrinking more and more heat is to be generated, and that thus we can conceive the sun even now to possess a sufficient store of energy to produce heat and light, almost as at present, for several million years of future time. For a few years Mayer's theory of solar heat had seemed to be probable; but I had been led to regard it as no longer tenable, because I had been iu the first driven, by consideration of the approximate constancy of tho earth's period of revolution round the sun for the last 2,000 years, to conclude that 'the principal source, perhaps the sole appreciably effective source, of sun-heat is in bodies circulating round the sun at present inside the earth's orbit; and because Le Verrier's researches on the motion of the planet Mercury, though giving evidence of a sensible influence attributable to matter circulating as a great nnmber of small planets within his orbit round the sun, showed that the amount of matter that could possibly be assumed to circulate at any considerable distance from the sun must be very small; and therefore, 'if tho meteoric influx taking place at present is enough to produce any appreciable portion of the heat radiated away, it must be supposed to be from matter circulating round the sun, within very short distances of his surface. The density of this meteoric cloud would have to be supposed so great that comets could scarcely have escaped as comets actually have escaped, showing no discoverable effects of resistance, after passing his surface within a distance of ⅛th of his radius. All things considered, there seems little probability in the hypothesis that solar radiation is compensated to any appreciable degree by heat generated by meteors falling in, at present; and, as it can be shown that no chemical theory is tenable, it must be concluded as most probable that the sun is at present merely an incandescent liquid mass cooling.' Thus on purely astronomical grounds was I long ago led to abandon as very improbable the hypothesis that the sun's heat is supplied dynamically from year to year by the influx of meteors. But now spectrum analysis gives proof finally conclusive against it. Each meteor circulating round the sun must fall in along a very gradual spiral path, and before reaching the sun must have been for a long time exposed to an enormous heating effect from his radiation when very near, and must thus have been driven into vapour before actually falling into the sun. Thus if Mayer's hypothesis is correct, friction between vortices of meteoric vapours and the sun's atmosphere must be the immediate cause of solar heat; and the velocity with which these vapours circulate round equatorial parts must amount to 435 kilometres per second, The spectrum test of velocity applied by Lockyer showed but a twentieth part of this amount as the greatest observed relative velocity between different vapours in the sun's atmosphere. At the first Liverpool meeting of the British Association (1854), in advancing a gravitational theory to account for all the heat, light, and motions of the universe, I urged that the immediately antecedent condition of the matter of which the sun and planets were formed, not being fiery, could not have been gaseous, but that it probably was solid, and may have been like the meteoric stones which we still so frequently meet with through space. The discovery of Huggins, that the light of the Nebulæ, so far as hitherto sensible to us proceeds from incandescent gas, seems at first sight literally to fulfil that part of the Nebular hypothesis to which I had objected. But a solution, which seems to me in the highest degree probable, has been suggested by Tait. He supposes that it may be by ignited gaseous exhalations proceeding from the collision of meteoric stones that Nebulæ and the heads of comets show themselves to us, and he suggested at a former meeting of the Association that experiments should be made for the purpose of applying spectrum analysis to the light which has been observed in gunnery trials, such as those at Shoeburyness, when iron strikes against iron at a great velocity, but varied by substituting for the iron various solid materials, metallic or stony. Hitherto this suggestion has not been acted upon; but surely it is oue the carrying out of which ought to be promoted by the British Association. Most important steps have been recently made towards the discovery of the nature of comets; establishing with nothing short of certainty the truth of a hypothesis which had long appeared to me probable—that they consist of groups of meteoric stones; accounting satisfactorily for the light of the nucleus; and giving a simple and rational explanation of phenomena presented by the tails of comets, which had been regarded by the greatest astronomers as almost preternaturally marvellous. The meteoric hypothesis to which I have referred remained a mere hypothesis —I do not know that it was ever even published—until, in 1866, Schiaparelli calculated, from observations on the August meteors, an orbit for these bodies which he found to agree almost perfectly with the orbit of the great comet of 1862, as calculated by Oppolzer, and so discovered and demonstrated that a comet consists of a group of meteoric stones. The essence of science, as is well illustrated by astronomy and cosmical physics, consists in inferring antecedent conditions, and anticipating future evolutions, from phenomena which have actually come under observation. In biology the difficulties of successfully acting up to this ideal are prodigious. The earnest naturalists of the preseut day are, however, not appalled or paralysed by them, and are struggling boldly and laboriously to pass out of the mere 'natural history stage' of their study, and bring zoology within the range of natural philosophy. A very ancient speculation, still clung to by many naturalists—so much so that I have a choice of modern terms to quote in expressing it—supposes that, under meteorological conditions very different from the present, dead matter may have run together or crystallised or fermented into 'germs of life,' or 'organic cells,' or 'protoplasm.' But science brings a vast mass of inductive evidence against this hypothesis of spontaneous generation, as you have heard from my predecessor in the Presidential chair. Careful enough scrutiny has, in every case up to the present day, discovered life as antecedent to life. Dead matter cannot become living without coming under the influence of matter previously alive. This seems to me as sure a teaching of science as the law of gravitation. How, then, did life originate on the earth? Tracing the physical history of the earth backwards, on strict dynamical principles, we are brought to a red-hot melted globe on which no life could exist. Hence, when the earth was first fit for life, there was no living thing on it. There were rocks solid and disintegrated, water, air all round, warmed and illuminated by a brilliant sun, ready to become a garden. Did grass and trees and flowers spring into existence, in all the fulness of ripe beauty, by a fiat of creative power? Or did vegetation, growing up from seed sown, spread and multiply over the whole earth? Science is bound, by the everlasting law of honour, to face fearlessly every problem which can fairly be presented to it. If a

probable solution, consistent with the ordinary course of nature, can be found, we must not invoke an abnormal act of creative power. When a lava stream flows down the sides of Vesuvius or Etna, it quickly cools and becomes solid; and after a few weeks or years it teems with vegetable and animal life, which has been originated by the transport of seed and ova and by the migration of individual living creatures. When a volcanic island springs up from the sea, and after a few years is found clothed with vegetation, we do not hesitate to assume that seed has been wafted to it through the air, or floated to it on rafts. Is it not possible, and, if possible, is it not probable, that the beginning of vegetable life on the earth is to be similarly explained? Every year thousands, probably millions, of fragments of solid matter fall upon the earth—whence come these fragments? What is the previous history of any one of them? Was it created in the beginning of time an amorphous mass? This idea is so unacceptable that, tacitly or explicitly, all men discard it. It is often assumed that all, and it is certain that some, meteoric stones are fragments which had been broken off from greater masses and launched free into space. It is as sure that collisions must occur between great masses moving through space as it is that ships, steered without intelligence directed to prevent collision, could not cross and recross the Atlantic for thousand of years with immunity from collisions. When two great masses come into collision in space it is certain that a large part of each is melted; but it seems also quite certain that in many cases a large quantity of débris must be shot forth in all directions, much of which may have experienced no greater violence than individual pieces of rock experience in a landslip or in blasting by gunpowder. Should the time when this earth comes into collision with another body, comparable in dimensions to itself, be when it is still clothed as at present with vegetation, many great and small fragments carrying seed and living plants and animals would undoubtedly be scattered through space. Hence and because we all confidently believe that there are at present, and have been from time immemorial, many worlds of life besides our own, we must regard it as probable in the highest degree that there are countless seed-bearing meteoric stones moving about through space. If at the present instant no life existed upon this earth, one such stone falling upon it might, by what we blindly call naturally causes, lead to its becoming covered with vegetation. I am fully conscious of the many scientific objections which may be urged against this hypothesis, but I believe them to be all answerable. I have already taxed your patience too severely to allow me to think of discussing any of them on the present occasion. The hypothesis that life originated on this earth through moss-grown fragments from the ruins of another world may seem wild and visionary; all I maintain is that it is not unscientific. From the earth stocked with such vegetation as it could receive meteorically, to the earth teeming with all the endless variety of plants and animals which now inhabit it, the step is prodigious; yet according to the doctrine of continuity, most ably laid before the Association by a predecessor in this chair (Mr. Grove), all creatures now living on earth have proceeded by orderly evolution from some such origin. Darwin concludes his great work on 'The Origin of Species' with the following words: 'It is interesting to contemplate an entangled bank clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately-constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us.' 'There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms, most beautiful and most wonderful, have been and are being evolved.' With the feeling expressed in these two sentences I most cordially sympathise. I have omitted two sentences which come between them describing briefly the hypothesis of 'the origin of species by natural selection,' because I have always felt that this hypothesis does not contain the true theory of evolution, if evolution there has been, in biology. Sir John Herschel, in expressing a favourable judgment on the hypothesis of zoological evolution, with, however, some reservation in respect to the origin of man, objected to the doctrine of natural selection that it was too like the Laputan method of making books, and that it did not sufficiently take into account a continually guiding and controlling intelligence. This seems to me a most valuable and instructive criticism. I feel profoundly convinced that the argument of design has been greatly too much lost sight of in recent zoological speculations. Reaction against the frivolities of teleology, such as are to be found, not rarely, in the notes, of the learned commentators on Paley's 'Natural Theology,' has, I believe, had a temporary effect in turning attention from the solid and irrefragable argument so well put forward in that excellent old book. But overpoweringly strong proofs of intelligent and benevolent design lie all around us, and if ever perplexities, whether metaphysical or scientific, turn us away from them for a time, they come back upon us with irresistible force, showing to us through nature the influence of a free will, and teaching us that all living beings depend on one ever-acting Creator and Ruler."

(Section G.)

ADDRESS.

By Professor Fleeming Jenkin, President.

In addressing you on the subject of mechanical science in our ancient university, I propose to speak on the somewhat threadbare topic of technical instruction. The panic with which some persons regarded the rapid improvement made abroad in manufactures has subsided, but I hope that you will be all the more ready on that account to listen to a few suggestions, as to steps which may be immediately taken to improve the education of those who apply science to practical ends. The subject does not owe its prominence to any events of to-day or of yesterday; it has long been, and will long be, of paramount importance to this country that the education of the producers of wealth should be such as will enable them, not merely to compete on advantageous terms with foreigners, but rather to master the great forces of nature by which we work. That we have gained some triumphs can be no reason for relaxing our efforts. With each advance further advance becomes more difficult, and requires more knowledge. The first rude implements and processes employed by man certainly required for their explanation or acquirement no book-learning; but as processes become complex, and implements develop into machines, as the occupations of men differ more and more, practice alone is found insufficient to give skill, and study becomes the necessary preparation for all successful work. Our first engineers were not learned men; strong good sense and long practice enabled them to overcome the comparatively simple questions with which they dealt. All honour to those great men; but we who have to deal with more complex, if not with vaster problems, cannot trust to good sense alone, even if we possess it, but must arm ourselves by the study of science and its application to the arts. This being granted, how shall it be done? I need not trouble you by refuting the absurdities of a few men, who would have those things taught by practice. What has been taught by practice must still be taught by practice. The business of the school is to teach those things which practice in an art will not teach a man. Let us apply this principle to engineering—the most scientific of all professions. It will be most useless to lecture on filing and chipping; it will be useless to describe the mere forms and arrangements of vast multitudes of machines; one kind of knowledge of the properties of materials can only be acquired, as it always has been acquired, by actually handling them; and the knowledge of the arrangement of a machine is far better learnt by mere inspection than from fifty lectures; moreover, it can be acquired by an intelligent man, even if he be wholly unlettered. Book-learning about estimates, the value of goods, methods of superintending work, and dealing with men, is foolishness. Written descriptions of puddling a clay embankment, excavating, and such operations, give no knowledge; and yet a vast mass of such knowledge must, at some time of his life, be acquired by the engineer, and the student cannot be employed as an engineer until he has laid up a store of such knowledge. Colleges cannot give him this; he must serve an apprenticeship in fact if not in form; young foreigners taught in colleges serve their apprenticeship, at the cost of their employers, during the first few years of their professional life. We call the tyro an apprentice or pupil, and he pays his master instead of being paid by him. I have the strongest feeling against any attempt to substitute collegiate teaching for practical apprenticeship; so far as colleges attempt to teach practice, they are and will be a sham in this country and in all others. The work of a college is to teach those sciences which are applied in the arts, but it can go a little further, and indicate to its students how the application is made in at least a few selected instances. Applying this dictum to the eduction of an engineer, his college can teach him mathematics, natural philosophy, chemistry, and geology. No one can doubt that a youth well trained in these branches of knowledge will, even with no further teaching, learn more during his apprenticeship, and during his whole professional life will take a higher standing, than the man of equal intelligence untrained in science. College can, however, do more than this; it is found that a lad will go through a considerable number of books of Euclid, and yet see so dimly how his knowledge is to be connected with practice that he may be unable even to compute the area of a field the dimensions of which are well-known to him; and far more is it seen that a man may be fairly grounded in mathematics, and yet have very little idea how to apply his knowledge to mechanical problems. It is the business of those who hold such chairs as mine to point out the connection between pure science and practice; to show how mathematics are employed in mensuration and in mechanical

calculations; to show how the truths of physics are made use of in designing economical machinery, as when we teach the connection between the laws of heat and the steam engine. The stndent who has once grasped the fact that there is a real connection between practice and theory will seldom be at a loss how to find or search for that connection in after-life. The student thus prepared knows what he has to learn from practice, and need not lose precious time in blundering over the numberless scientific problems which practice is sure to suggest but can never solve. The education of the architect, the practical chemist, the manufactnrer, and the merchant, mnst be similar, *mutatis mutandis*, with that of the engincer. Assuming, then, that the education of those who are to follow more or less scientific pursuits mnst consist in acquiring, first, that theoretical knowledge which practice cannot give, and, secondly, the practical knowledge which schools shonld not attempt to give, there remains the question whether the theorctical preparation should be given in special colleges, or universities such as our own. I have no hesitation in preferring the nniversity. Mathematics, physics, chemistry, geology, botany, languages all form elements required in varions combinations in the edncation of all our students. There is but one kind of mathematics, one kind of pure physics, and so forth. Surely it is better that we should teach the men belonging to different professions side by side, so long as the matter tanght is to be the same. There are many dangers in an opposite course. There are not a sufficient number of competent teachers to allow of mnch differentiation. Segregation at an early age is apt to foster professional peculiarities and narrow-mindedness. There is great danger, if physics are to be tanght specially to engineers, that a special kind of physics, erroneously supposed to be specially useful to them, will be invented. Lastly, the contact of students and professors of one faculty with the students and professors of other faculties is very beneficial to all. Do not, therefore, cripple old universities by withdrawing from them a portion of their students and their professors, to set np special, professional, or technical colleges of a novel kind, but rather add by degrees to the power and usefulness of old institutions, and found new colleges and universities after the model of those which are found to have done good work. As an example of what may be safely done, I consider that in Edinburgh we require a chair of architectnre, and lectnreships on navigation and on telegraphy. There is, further, much want of a teacher of mechanical drawing. The professors of physics and chemistry require additional accommodation for practical laboratories, and additional assistance. If these additions were made, our college would, in my opinion, meet all the requirements for superior technical education in this part of Scotland. For £2,000 per annum all these additions might be made. Notwithstanding the acknowledged importance of education, establishments for giving the higher kinds of instruction are never self-supporting, and students mnst everywhere be bribed to come and learn. Immediate prizes, in the form of bursaries, scholarships, and fellowships, are required to induce men to cultivate the older fields of learning; and similar bribes are needed to promote the tillage of the more recently colonised domains of applied science. The Whitworth scholarships are a noble example of munificence thus directed, althongh, in my opinion, the examination requires considerable reform. I hope that further benefits of this kind will be conferred on those colleges which give efficient teaching. Local ambition is most effectnally stirred by local prizes, and I regret to find a certain apathy among students here with respect to the Whitworth competition. This appears to arise partly from dissatisfaction with the mode of examination, and partly from the fact that the examiners are men not well known in Scotland. Leaving the question of technical training for the upper classes, and the still larger question of scientific teaching in second grade schools, the consideration of which would lead us too far a-field, I purpose to say a few words on the technical education of the skilled artisan. This we must treat on the same principles as have been applied to professional teaching. We must endeavour to prepare the lad in school, by teaching him those things which he cannot learn in workshops, but which will enable him to work with greater intelligence while acquiring and applying his practical knowledge. I shall not now speak of that general education which should make him a good man, and which should open to him those great sources of rational enjoyment arising from culture; I will restrict myself entirely to his preparation for becoming an efficient workman. I have in many places said, and I cannot say too often, that the great want of the workman is a knowledge of mechanical drawing. Unfortunately, I can obtain little attention from the general public to this demand for the workman. Very few persons not being engineers know at all what mechanical drawing is. I am sorry to say that some examiners in high places, who direct the education of the country, know very little more than the general public, and teachers who should give bread give chaff. I have lived much abroad, and come into close contact both with English and foreign workmen, and I unhesitatingly say that that the chief, if not the only inferiority of Englishmen has been in this one branch of knowledge. I must explain to some of my hearers what mechanical drawing is. It is the art of representing any object so accurately that a skilled workman, upon inspecting the drawing, shal be able to make object of exactly the materials and dimensions shown, without any further verbal or written instructions from the designer. The objects represented may be machines, implements, buildings, utensils, or ornaments. They may be constructed of every material. The drawings may be linear, shaded and coloured, or plain. They must necessarily be drawn to scale, bnt varions geometrical methods may be employed. The name of mechanical drawing is given to one and all those representations the object of which is to enable the thing drawn to be made by a workman. Artistic drawing aims at representing agreeably something already in existence, or which might exist, and for the sake of the representation; mechanical drawing aims at representing the object, not for the sake of the representation, but in order to facilitate the production of the thing represented. Now, I say that it is this latter kind of drawing which is so vastly important to onr artisans, and hence to our whole wealth-producing popnlation. Very few workmen, or men of any class, can hope to acquire such excellence in artistic drawing that their productions will give pleasure to themselves and others; bnt a great number of workmen mnst acquire some knowledge of the drawings of those things which they produce; and there is not one skilled workman or woman who would not be better qualified by a knowledge of mechanical drawing to do his work with ease to himself and benefit to the public. Mechanical drawing is a rudimentary acquirement, of the nature of reading, writing, and arithmetic. In order that a man may understand the illustrated description of a machine, he must understand this kind of drawing. To the general public, an engineering drawing is as unintelligible as a printed book is to a man who cannot read. The general public can no more put their ideas into such a shape that workmen can carry them out, than a person ignorant of writing can convey their meaning on paper. Reading and writing on mechanical or industrial subjects is impossible without some knowledge of the art I am pressing on your attention. This art is tanght abroad in every industrial school; a great part of the school time is given np to it. In a Prussian indnstrial school one-third of the whole time is given to it. A French commission on technical education reported that drawing, with all its applications to the different industrial arts, should be considered as the principal means to be employed in technical education. Now, I deliberately state that this subject is not tanght at all in England, and that the ignorance of it is so great that I can obtain no attention to my complaints. A hundred times more money is spent by Government to encourage artistic drawing than is given to encourage mechanical drawing, and I say that mechanical drawing is a hnndred times more important to us as a nation. Moreover, the little *quasi*-mechanical drawing which is taught is mostly mere geometrical projection, a subject of which real draughtsmen very frequently, and with little loss to themselves, are profonndly ignorant. Descriptive geometry and geometrical projection are nearly useless branches of the art, and the little encouragement which is given is nearly monopolised by these. Mechanical drawing proper is confined to those who pick it np by practice in engineering offices. These draughtsmen are often excellent, and on their behoof I claim no other teaching. I speak for the artisan who makes and for him who uses machinery. There are two ways in which onr shortcomings may be remedied. First, the schools of art now established in this country should be enlarged so as to teach real mechanical drawing, and the examinations conducted by the Science and Art Department should be greatly modified; secondly, the drawing which is to be taught in the schools under the superintendence of the new school boards may be and ought to be mechanical drawing. Freehand drawing, as a branch of primary education, will, I fear, be a useless pastime; but whether that be so or not, I am certain that the accurate and neat representation of the elementary parts of machinery and buildings would be popular with the pupils, and could be effectively taught. This kind of drawing educates hand and mind in accuracy, it teaches the students the elements of mensuration and geometry, and it affords considerable scope for taste where taste exists. The chief difficulty will be to obtain competent teachers. I should occupy you too long were I to attempt to show how these must themselves be trained. My chief aim to-day has been to claim attention for a most important and wholly neglected branch of education. I shall probably be expected to urge the teaching of other natural sciences in onr primary schools; nothing, indeed, would give me greater pleasure than to think that this conld be done. I confess I doubt it, and while onr second grade schools are what they are in this respect, and while the Cambridge examination for a degree in applied science is what it is, I dare not think of natural science classes in our primary schools. I shall be delighted if I am mistaken, but I am certain that mechanical drawing deserves our first attention, as most immediately useful to the artisan, and most easily taught. The very books on natural science

which are pnblished in England cannot be properly illustrated for want of competent draughtsmen, and children would be nnable to follow the illustrations and diagrams if ignorant of the principles on which they are constructed. I look rather to good reading books, explained by intelligent masters, as the best manner of teaching the elementary and all-important truths of natural science. No man conld do better service than in compiling such reading-books, and there are few wants more urgent than that of masters competent to enlarge npon texts which would thus be put into their hands. The cducation of our workmen is far more incomplete than that of our professional men. Small additions to existing institutions will meet the want of the latter; but for the former the institutions have to be erected almost from the foundation.

ON THE RAINFALL OF SCOTLAND.

The following is an abstract of an interesting paper upon this snbject by Mr. Buchan:—

The paper was illustrated by a map, showing the average annual rainfall at about 290 places, many of the averages being dedneed from observations carried on through a long series of years. The map brought out the large rainfall in the west as compared with the east, a difference which was strongly marked even in the group of the Orkney Islands. The average rainfall in the west, at stations removed from the inflnence of hills, was about 40in.; but on the east coast, in similar situations, the rainfall was as low as from 24in. to 28in. In casting the eye towards the watershed of the country rnnning north and south, there occurred rapid, but by no means uniform, decrease. The places of longest rainfall were:—Glencorse, 128in.; Ardlin, head of Loch Lomond, 115in.; Bridge of Orkney, 110in.; Tyndrum, 104in.; Glen Quoich, 102in.; and Portree, 101in. At no great distance from several of these places the rainfall was by no means excessive, and this pointed ont an enormons difference of climate between places not far apart. The distribntion of the rainfall was very instructive in many districts, as in the valley of the Forth, from the head of Loch Katrine to North Berwick, where the amount varied from 91in. to 24in.; in Clydesdale, where the qnantity was greatest at the head and foot of the valley respectively, being considerably less at intermediate places; and along Loch Linnhe and through the Caledonian Valley, where the variations of the rainfall were very excessive. If those districts were marked in which the rainfall did not exceed 30in. annnally, the great grain-producing district of Scotland would be indicated; and it was interesting to note that in those districts which prodnced the best wheat the rainfall was lower than elsewhere. The writer of the report hoped that the Association wonld give increased grants towards the securing of adequate retnrns of rainfall.

ON ROAD STEAMERS.

By R. W. Thomson.

The question of traction engines or steam locomotives to work on common roads is a very old one, being of much more ancient date than railways. The attempt to construct a steam engine to run on a common road is probably the most difficult enterprise that mechanical engineering has ever attempted. It is the distinctive character of steam mechanism that it requires to work under almost uniform conditions, as under these alone can the precision of repetition be attained; and it is altogether wanting in the faculty of adapting itself to circnmstances. Even in ocean steamers, which at first sight may appear an exception to the rule, the machinery always performs the same definite functions. The path over which the vessel travels is always a yielding one, and whatever vicissitudes the hull may be exposed to from the state of the sea, the engines themselves are so protected that they remain nnaffected by these, and continne their own unchanging task. Now in constrncting traction engines, engineers had to meet requirements of a very different nature. They had to produce an engine which should work with perfect accuracy and at the same time have the faculty of adapting itself to the most varying circumstances. It would now have to run over a hard, now over a soft road; over wet, dry, and slippery roads. It wonld have to climb hills and descend them, to pick its way over obstacles, to endure severe shocks, and to take a firm hold of all kinds of surfaces. After trying for a while, the engineers found it so difficult to bnild a machine to fit such different conditions that they thought they would try if they could not bring the conditions to fit the machine. A uniform snrface, and as little change as possible in level were the points to attain, and these were achieved by laying down rails. The mechanical part of the system, namely, the engines, having now only to fnlfil their legitimate duty of performing one kind of work with perfect accuracy, became an alluring field for improvements; and so many minds devoted themselves to their elaboration that now, after two generations from the commencement of the scheme, we find that a very high stage indeed of perfection has been reached. But notwithstanding the inappreciable value of railways they still left unfulfilled the want of some means other than animal power of transport in localities where no permanent way could be laid; so once more engineers set themselves to the task of building an engine which shonld be able to do all manner of things. The problem was scarcely a scientific one, or rather it was not treated in a scientific manner; and those who engaged in it for many years carried on a sort of rude contest between road and engine. When it was found that the rough road broke the machinery, the engine was made so heavy that it destroyed the road. When it was found that the surface of the ground would offer no hold to the wheels, the wheels in revenge, as it were, were provided with claws which gripped the ground, bnt tore it wofully.

At last Mr. Boydell once more thonght of dealing with the qnestion from a scientific point of view—that is to say, he endeavoured to prodnce a certain nniformity of conditions under which the engine was to work, and to this end provided the wheels with wooden blocks, which laid themselves down in a kind of endless railway. Bnt although theoretically he had been working in the right direction, practically his invention was not a success, as it was impossible to keep the appendages to the wheels from breaking. More years went by, and it then occurred to the inventor of the roak steamer to surround the wheels of his engine with a thick tyre of india-rubber. By this means he sought and obtained a very considerable degree of uniformity of condition, becanse he had, as it were, spread under his wheel a thick carpet of solid india-rubber 4in. or 5in. in depth. This to a great extent obliterates the ineqnalities of the road, and makes it a matter almost of indifference whether the road be hard or soft. Not only does this india-rubber carpet or cushion completely prevent all hard shocks to the machiney—shocks which, passing over paved streets, are quite destrnctive to ordinary traction engines—bnt it further saves the road from the grinding action of the iron wheels, which are so terribly injnrious to the pathways over which they travel. No regular traffic conld be carried on with a common traction engine, weighing 10 or 12 tons, with rigid wheels, withont excessive injury to the road, for not only will the hard wheels cnt and crush the road, bnt their destructive action is greatly aggravated by the absolute necessity for having some kinds of projections or teeth to take hold of the road, so as to prevent the wheels from slipping. This has been a very serious objection to the use of these engines, and has raised great opposition to them on the part of road trustees and others concerned in the good condition of the highways. The india-rubber tyres, while they preserve the machinery from all shocks and conseqnent breakages, likewise preserve the road from all injury; and it is stated by those who have watched the action of regular traffic by means of road steamers that india-rubber tyres actually improve the roads. Mr. John F. White, an extensive miller in Aberdeen, who has been using a road steamer for the last two years, say: "I think there can be no doubt that a road steamer improves a well-made road. I can prove this conclusively. Indeed, I have never heard this doubted in this quarter by any competent authority." Mr. Woolsey, a large brewer in Ireland, who has been working a road steamer for the last ten months, says: "We can produce road contractors and a county surveyor to depone that our road steamer improves the roads." In conseqnence of the absence of all hard shocks and blows, the engines mounted on india-rubber tyres can travel at a very much higher speed than machines mounted on rigid tyres. For short experimental trips a speed at the rate of from 15 to 20 miles an hour has been accomplished, and continnous journeys at the rate of 10 miles an hour offer no difficulty whatever. The amonnt of adhesion obtained by the use of india-rubber tyres is very mnch greater than in the case of rigid wheels. In the latter case, the amount of adhesion is extremely varions. On smooth paved streets so little as to be practically valueless. On sandy roads also it is too little to be of any use; and on muddy roads it is even reduced to a very low point. Whenever a traction engine with rigid wheels has to travel over any of these snrfaces it is obliged to arm itself with various appliances in the shape of spnds, claws, or paddles, which are all more or less weapons of destruction to the road. India-rubber tyres, on the contrary, maintain a singularly uniform degree of hold upon the road, whatever may be the nature of the surface. The only kinds of soil on which the india-rnbber tyres cannot work are ground so soft as the flow away from under the wheel or wet clay, which has a tendency to ball upon the wheels, and so impede the action of the india-rubber. In these exceptional cases, spuds or paddles, such as are used on ordinary traction engines, may likewise be temporarily fixed to the wheels of the road steamer; bnt it is very undesirable to allow any kind of engine to work upon land in this condition, as the injury cansed by the passage of the wheels is so great as to be very mnch in excess of the valuc of any work done. In its ordinary work on a farm, which shonld always be carried on when the ground is dry and in a suitable condition, the road steamer requires none of these appliances: but it is well to provide it with them for any special

emergency for agricultural work, as it never requires anything of the kind for road traction work. It may here be mentioned that when the road steamer was first applied to farm work, it came out very clearly that a great deal of the steamer's efficiency would depend upon the proportion of the lightness of the engine to the thickness, breadth, and diameter of the india-rubber tyres. It was found that an engine weighing nearly 7 tons, mounted on tyres 9in. wide, could not move itself over a damp, heavy clay field; whilst an engine weighing 6½ tons, but mounted on tyres 12in. wide, was not only able to travel itself with ease over this field, but was also able to haul the engine with narrow tyres and a 3-furrow plough, which was attached to the narrow-tyred engine in such a way that it could not be easily removed. Seeing, then, that the extra breadth of tyre enabled the one engine not only to move itself, but to pull the other engine behind it, and to plough three furrows on this heavy land, it was determined that all steamers built for farm purposes should be mounted on tyres of much greater width than those intended for road work; and the tyres of all the farm steamers are now 18in. broad, which enables the engine to travel over any kind of ground that is in a sufficiently dry condition to be worked upon without detriment to the soil itself.

Recently, at the Royal Agricultural Show at Wolverhampton, some competitive trials took place between road steamers, with india-rubber tyres, and traction engines with rigid wheels. Two road steamers and three traction engines took part in these. The first trial consisted in the engines having to travel round some rough and very uneven fields. The ground was dry. The engines had no loads behind them. The distance was 1¾ miles. The quickest road steamer went round in 15 minutes; the quickest traction engine in 23 minutes.

The next trial consisted in the same engines going over the same course with loads. On this occasion it had rained continuously for twenty-four hours, and the wet loam was so greasy that it would offer a hold to no kind of wheel. The traction engines all appeared armed with great spikes and paddles, which they so frequently need, but the road steamers were not provided with such appliances. The road steamer Sutherland, which was to compete in this trial, though entered as a farm steamer, lacked the distinctive qualification of Mr. Thomson's farm steamers, its tyres being only 12in. broad instead of 18in. Moreover, the engines which Mr. Thomson mounts on these tyres weigh about 7 tons, while the Sutherland's weight was 10 tons 4 cwt. It was decided that the engines should draw lots as to which should go first, and the right of precedence fell to a traction engine with large spuds. It was further ruled that the succeeding engines must follow exactly in the track of predecessors. The road steamer Sutherland drew No. 2. The traction engine with its big spuds clawed its way round the course, slipping occasionally, and then with its great spikes digging big holes. When it had completed its round, the road steamer Sutherland had to follow in its course, and when it came to the great holes dug by the spudded engine it had very great difficulty, owing to the wet greasy nature of the soil, in getting through them; and, by-and-bye, when the state of things was rendered even worse by a thunderstorm which converted the ground into a swamp, it had to throw off its load, and only with great difficulty, and after several hours succeeded in completing its round. This, as will be seen, was not a trial between rigid wheels and elastic tyres, but was a trial between wheels armed with spuds and paddles and wheels with no spuds. No rigid wheel without such appliances could have travelled 100 yards over this ground; and had it been thought right to use spuds, the road steamer would have derived far more advantage from them than the rigid wheeled engine, and could have gone round with greater ease. But the test was a purely artificial one, for any one witnessing the havoc which these spuds had made with the land would at once perceive that no farmer would ever dream of sending an engine upon his land in that state for any practical work. A very marked illustration of the value of the very broad india-rubber tyres for engines required to work on soft land is the fact, that while the road steamer Sutherland with such great difficulty moved itself over the course in a neighbouring county, on land in precisely the same condition, and during heavy rain another road steamer, with tyres 18in. broad, in the presence of a large company, was ploughing, by direct traction, 5½ acres in 5½ hours.

The third trial consisted in a journey of all the engines from Wolverhampton to Stafford, with loads proportionate to their nominal horse power. The distance was 16 miles, and the road steamer Sutherland beat all the other engines by 45 minutes.

The fourth trial consisted in a rigid wheeled traction engine and a road steamer having to travel over a measured course with maximum loads. The 8-H.P. road steamer Sutherland took 36 tons over this course in 10 minutes, and with perfect ease. The 10-H.P. rigid-wheeled traction engine took 38 tons over the same course in 50 minutes with considerable slipping and difficulty, showing that the road steamer would do as much work in 2 hours as the rigid wheeled engine would do in 10 hours. After this a very interesting experiment was made. The 8-H.P. road steamer Sutherland, which, with its elastic tyres, had taken 36 tons over the course, had its wheels removed, and rigid wheels substituted, and with these it was found that it could only take 23 tons over the same course, giving a difference of 13 tons in favour of the india-rubber.

EXPLOSIVE AGENTS

By F. A. ABEL, F.R.S., Treas. C.S.

The following is an abstract of an interesting paper upon the above subject:—

The author first directs attention to gunpowder, briefly noticing its manufacture, and the causes which operated in demanding a reduction of the violence of its action. So long ago as 1858 a committee was formed for deciding upon the best powder for the Enfield rifle, and they were afterwards directed to investigate the question of cannon powder with a view to modifying its violence. This led in 1860 to the introduction of the rifle large grain powder, and subsequently, in 1864, to the use of pellet powder. The principles laid down by the first committee on gunpowder, in 1858, as their guide in attempting to reduce the violence of the action of that material when fired in large charges were based upon mechanical considerations, and have been adhered to ever since. As gunpowder is simply an intimate mechanical mixture of a powerful oxidising agent, saltpetre or potassium nitrate, with two readily oxidisable substances, sulphur and carbon or charcoal, the behaviour of the mixture, and the nature of the results furnished by its explosion are susceptible of great modification by variations in the proportions of its ingredients. In fact, the explosive action of gunpowder is susceptible of very extensive modification by variations of its composition. There are, however, certain proportions which appear best as furnishing the largest amount of gaseous matter compatible with the development of the highest temperature. This is independent of other considerations affecting the question. It was upon considerations relating to the chemical action of the ingredients of gunpowder that the committee came to the conclusion that in attempting to moderate its violence, when used in large charges, it was unadvisable to make any change in its established composition which might be productive of a diminution of the total pressure developed by a charge unless the desired results were unattainable by modifying its mechanical and physical powers. In other words, they were desirous of effecting their object by introducing changes in the preparation of gunpowder and in the form in which it is employed. A very few experiments served to demonstrate that the rapidity of explosion of gunpowder was readily susceptible of great reduction by simple mechanical means. These means have, therefore, been adhered to by the present committee on explosives in developing the powder now used for heavy guns. There are five different points affecting the modification of gunpowder, and these are: the size of the grains. their form, the mechanical condition of their exterior, their density, and their hardness. The first promising results obtained were arrived at by simply increasing the size of the grains. Subsequently it was found that these results were still further improved by paying attention to the density and hardness of the powder, and by promoting the uniformity of these properties. A vast number of experiments have been made by various investigators into the nature of the action of fine gunpowder from the beginning of last century, when M. de la Hire took up the question down to the present day. These experiments include those made by Robins, by Count Rumford, by Colonel Caralli, by Major Rodman in the United States, by Captain Noble in England, and by various committees both at home and abroad. The methods adopted by the experimenters, as well as the results obtained by them, are given by Mr. Abel, who describes at some length the ingenious chromoscope devised by Captain Noble. A comparison of the results of experiments made by means of the chromoscope and a 10-inch gun, with R.L.G. powder, with the Russian prismatic powder, and with pebble powder, demonstrate the superiority of the latter. By employing pellet or pebble powder as now manufactured not only is the strain upon the guns up to those of 25 tons greatly reduced when velocities equal to those furnished by the R.L.G. powder are attained, but considerably increased effects are obtained from these guns without submitting them to a greater strain than they would be exposed to in employing the former service powder to obtain the standard results. In dealing with the 35-ton gun, however, the author refers to the unsatisfactory results afforded by the new powders, and observes that further modifications in their manufacture will possibly have to be introduced to meet the requirements of the case. The subject is now receiving careful attention in several quarters, and Captain Noble is pursuing a special line of in-

vestigation in reference thereto. Captain Noble's experiments promise o throw important additional light upou the nature of gnnpowder as a propelling agent. They cousist in exploding powder in close chambers on the plan adopted by previons experimenters with modifications afforded by the advanced state of science. The conclusions arrived at by Count Rumford and by Major Rodman, as regards the pressure exerted by gunpowder differ greatly from each other, as well as from the conclusious arrived at by Bunsen and Schischkoff in 1857. The heat developed was by these latter experimeuters estimated at 5980 deg. Fah., and the pressnre at 4374 atmospheres, or about 29 tons per square inch. But recent experiments made by Berthelot during the recent memorable siege of Paris appear to have shown that Bunsen and Schischkoff's estimate of the pressure of fired gunpowder is too low, just as Piobert's, which fixes it at 9600 atmospheres, or 64 tons, is considered too high. Some experiments made by Karolyi, in which he exploded small charges under conditions more nearly approximating to those of the actual employment of gunpowder, furnish results not greatly at variance with those of Bunsen and Schischkoff. The value to be attached to them, however, appears likely to be definitely determined before loug by the experiments upon which Captain Noble is at present engaged. In irou vessels of great strength he explodes by electric agency charges of gnnpowder ranging up to 2lb. The space iu which the charges are fired is varied from that entirely filled by the powder to that in which the latter occnpies only ten per cent. of the space. The vessel is fitted with a crusher gauge, by which the maximum pressure developed by the explosion is recorded. The gases are in all instances entirely confined, and are allowed to escape gradually, as soon as expedient after the explosion, with a view to the measurement of their volume, and the collection of portions for analysis. The examination of the gaseous and solid products has been undertaken by Mr. Abel, who observes that it would at present be premature to refer to the results obtained so far. He states, however, that the maximum pressure of fired gnnpowder, nnrelieved by expansion, has been found to be abont 40 tons per square inch. The tension and density of the gases from powder fired in a close chamber are found to be very similar to those of powder bnrued iu the bores of guns. Passsing on to the consideration of the substitution of other explosive agents for gunpowder, Mr. Abel observes that for small arms and artillery no rival has yet established any good claims to success as a propelling agent. He first notices guncotton, which he does not think will ultimately prove useful for larger artillery than field guns, although he does not predict even this applicatiou. White gunpowder and other chlorate mixtures are noticed, and their danger in mining operations pointed out. The application of these violent explosives to shells are then referred to, and the experiments for ascertaining their relative susceptibility to explosion are described. These experiments consisted iu placing definite quantities of the materials between flat brass plates, placing them upon a rigid support, and allowing weights to fall upon them from different heights. By varying the weight employed and the surface and thickness of the layer of explosive material operated upon some interesting and probably useful results are obtained. These experiments are now being carried out, and will be reported in due course by Mr. Abel. Nitro-glycerine in the form of dynamite has been tried at Shoeburyness for shells, but a want of confidence in nitro-glycerine preparations, aud the excess of explosive power they possess has led to a search for some other explosive for shell charges. This has been discovercd by Mr. Abel in one of the salts of trinitro-phenic acid or picric acid, which, from experiments recently made at Shoeburyness, and recorded at the time, appears likely to be introduced into the service as a material for shell charges. Mr. Abel next notices lithofracteur as a destructive agent, referring to its use by the Prussiaus during the receut war. He then touches upon dynamite, which was used by the French also during the war. The author then refers back to gun-cotton, and to the experiments that have been made with it, and the improvements which have been made in it since the British Association meeting in 1862. The chief improvement, and that which has placed it much more under control than it formerly was, is Mr. Abel's pulping process, supplemented by compression by hydraulic power. The safety from accidental explosion aud the power of this substance, together with the method adopted in firing it with a detonating fuse, are then successively dealt with by Mr. Abel, who finally details the various practical experiments which have been made from time to time in the demolition of stockades and other military strnctures, and which demonstrate the applicability of compressed guncotton to snch purposes. Mr. Abel's paper shows that the prodnctiou and utilisation of these powerful agents of destructiou and these indispensable auxiliaries in the development of indnstrial resources have been advanced in an unprecedented manner within the last few years. It further renders it clear that much remains to be learned regarding their nature and operation, and the conditions to be fulfilled in their most efficient application in many important directions.

ON THE RAINFALL OF GREAT BRITAIN.

By Mr. G. J. Symons.

The organizatiou under the superintendence of the committee was believed to be in a generally efficient state. With a staff of observers nnmbering nearly 2,000, spread over the whole extent of the British Isles, there could, however, be no question that, to insure perfect efficiency and uniformity of observation, a systematic inspection of the stations was absolutely necessary. Want of funds had prevented the committee from employing a regular inspector. Having called attention to the experiments with pit gauges, the report proceeded to state that, of course, it was not to be expected that the resnlts of a single year should agree exactly with the mean of two or three years, still less when the size of the gauge nsed was different, and the locality so opposite as the iuland district of Calne and the rockbound Yorkshire coast. It was, therefore, satisfactory that in only four months out of 11 did the ratios at Calne and Hawsker differ more than three per cent. In April, June, and November they were identical. The secular variatiou of rainfall, or the relative dryness aud wetness of different years and groups of years, was one of the most importaut and difficult branches of rainfall work. During the last 40 years, according to the mode of investigatiou, principally based on English returns, three out of the four decades had a rainfall nearly identical, and the other (1850-59) considerably below them, the deficiency being nearly 7 per cent. From the tables submitted it appeared that the amount of rain which fell in the ten years (1830-39) was similar to that which fell in the ten following years, the difference being a decrease, but scarcely 1 per cent. The investigation in report of 1866 shows an increase of 1·2 per cent., and the returns ceasing in 1850 show several cases of absolute identity. The committee then proceed to say :—With one investigation leading to a decrease of 1 per cent., another to an increase of the same amount, and a third to identity, we are led to the conclnsion that the two decades may be considered to show similar results. This is a mnch more important fact than it at first appears, and for this reason :—While there are ouly about a dozen registers complete for the three decades, there are 38 which are complete for the last four decades. Now that we have found the relation between the first two decades, the returns for the thirty years are rendered almost as instructive as those for 40 year. We have, therefore, compiled another table, which differs from the former only in its being for 30 years instead of 40, aud in giving observations from 38 statious instead of 12. The relative rainfall of the three decennial periods therein given, viz., 1840-49, 1850-59, and 1860-69, is showu on the map by means of curves. Whence of course it will be seen at once that the rainfall of the secoud decade (1850-59) was less than either that which preceded or followed it. Now, if we refer to the curve given by the calculations made in 1865, we shall find an almost identical depression, which strikingly proves the trustworthiness of the method then adopted. From the above table and diagram the remarkable similarity of the results obtained by the two dissimilar modes of investigation is reudered so obvious that it is unnecessary to dwell further upon it. We therefore proceed to the second part of our investigation—namely, to consider the distribution of the rainfall of the last decade, during which we have already nearly 400 perfect sets of observations. As each set of observations comprises more than 1,000 entries, and the table contains the result of nearly half a million observations, it is probable that it contains some slight percentage of errors, but we have no suspicion of the existence of any which appreciably affect the results. From the figures which were given the report stated that it would be seen that the probable average at Seathwaite is 141in. instead of 154 as shown on the map, or 7 per cent. less. A similar but generally less correction may be required for other stations. The figures must not, therefore, be considered as showing the true mean fall at the several stations, but only as approximations generally pretty close. The *data* in our possession, if corrected in accordance with the method explained, would afford more accurate results, but the investigation is altogether beyond our present resources. Large tracts of Ireland and even of Scotland are left blank in the map for want of observers. Much has recently been done to remedy these deficiencies, but there are still many localities where observations are deficient; we shall gladly receive any offers of assistance from those who have residences or property iu those parts, and our secretary will readily advise them as to instruments.

A prospectus has been issued of the Southwark and City Subway Company, with a capital of £100,000 in shares of £10, for making an undergroond subway from St. George's Church, in the Borough, to Arthur-street, on the City side of London Bridge, on the principle already carried out in the Tower Subway, which passes under the Thames between Southwark aud Tower-Hill.

HYDROSTATIC WEIGHING MACHINES.

By Mr. F. E. DUCKHAM, Millwall.

Visitors to the International Exhibition may see in the Department for Scientific Inventions a very compact and ingenious apparatus for weighing heavy bodies whilst they are being lifted, exhibited by Mr. J. Cowdy, of Queen-street, Cannon-street. It will be seen from the accompanying engravings, Figs. 1, 2, and 3, that the machine occupies but

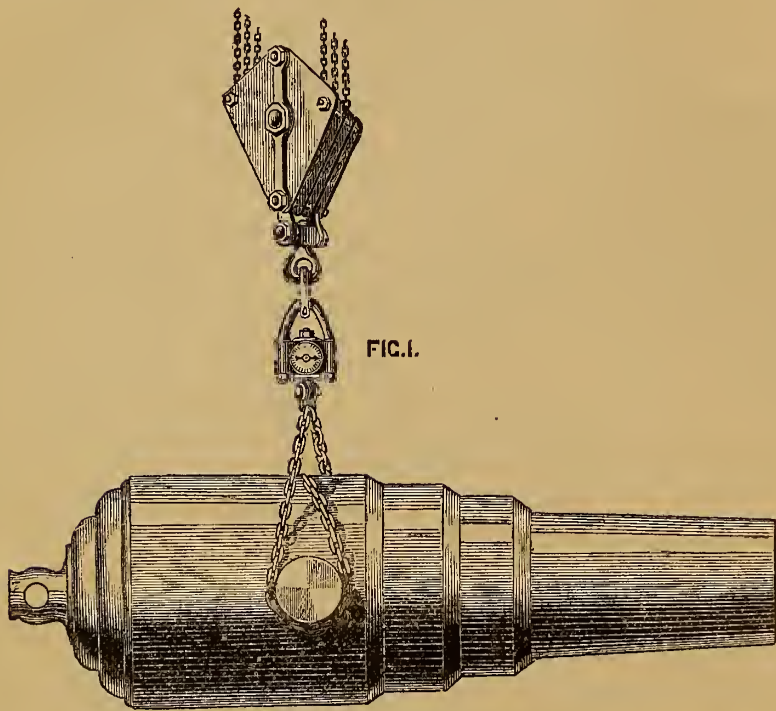


FIG. I.

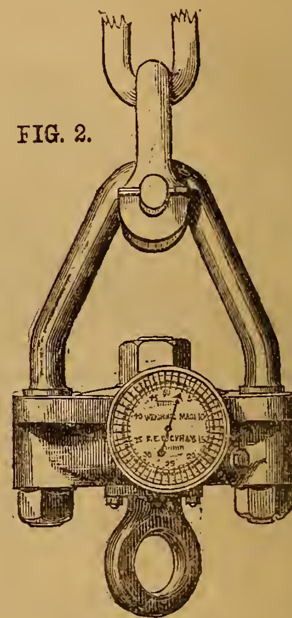


FIG. 2.

little space, and may be advantageously used in the place of the overhauling weight usually attached to cranes or other lifting apparatus. The principle upon which it acts is exactly similar to that of a hydraulic press inverted, as will be evident upon inspection of the section shown in Fig. 4. The hydraulic cylinder is fitted with a piston having a cup leather to keep it tight, the lower part of such cylinder being filled with oil or water. In practice, however, oil is found to be preferable to water, as being less liable to leakage, besides keeping the parts free from oxidation.

The action of the machine is so evident that but little description is required. The substance to be weighed is hung from the eye connected to the piston-rod of the machine, and lifted off the ground; the entire

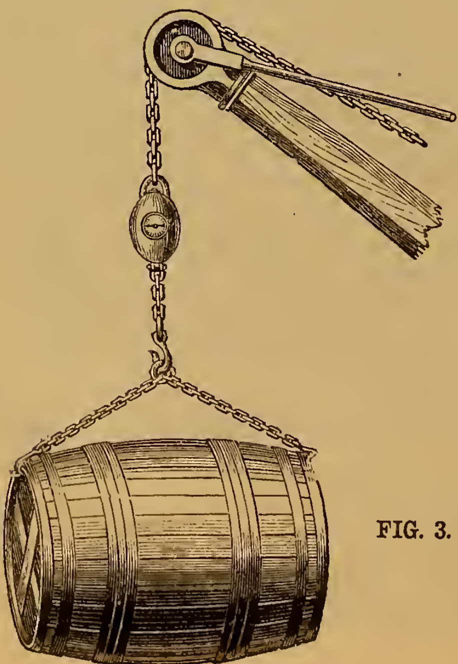


FIG. 3.

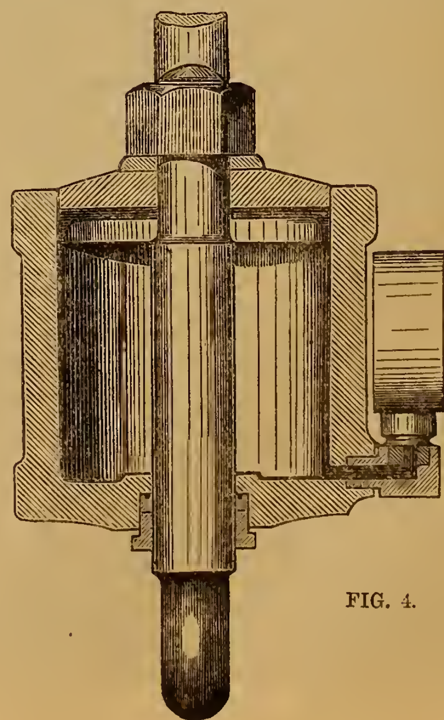


FIG. 4.

pressure due to the weight being thus born by the piston pressing against the oil in the cylinder. The pressure thus obtained is transmitted by means of the small tube shown at the bottom of the cylinder to a pressure gauge made for the purpose, and registered accordingly. Thus, supposing a weight of 5 tons be lifted by one of these machines, the diameter of the cylinder of which was barely 8 inches, or 50 square inches in area, the pressure per square inch would be 224 pounds—a pressure which is by no means beyond the capabilities of a gauge. It might be objected that the oil was liable to leak slightly through the stuffing-box below, or the cup leather above, but even supposing such to be the case, it would not alter the accuracy of the machine, unless, indeed, the whole of the fluid ran out. In practice, however, it is found that very little leakage occurs, and no inconvenience has been experienced from that cause.

The machines have been used at the Millwall Docks for more than a year, during part of which time they were used for checking the weight of the armour-plates of the *Abyssinia*, lately built by Messrs. Dudgeon, when their accuracy was found to be very perfect. From this it will be evident that by attaching one of these machines to the chain of a crane the weight of the goods raised or lowered may be registered without the slightest difficulty. For weighing goods whilst being hoisted or lowered we know of no apparatus equal to it either in economy or simplicity.

WOOD PULP FOR PAPER.

This production is known to offer considerable advantages over the pulp of esparto grass, or other materials of the same nature used for paper-making. It is capable of producing any description of paper, from the coarsest kinds to the most finished writing-paper, and may now be made a very simple and comparatively inexpensive process. By Sinclair's patent wood pulp machinery, the cost of production to the unbleached stage is £8 per ton. About 42 cwt. of wood makes 1 ton of paper or dry pulp. Although the best white pine wood, at a cost of from £2 10s. to £3 per ton, is selected for the most perfect samples, coarser and even damaged wood, which can be obtained in almost any quantity at about £1 per ton, is largely used for the inferior qualities of paper. The wood is first chipped up into thin pieces of about 1in. broad, 2in. to 3in. long, and ½in. thick. It is then put into the boiler, and a solution of caustic soda poured over it, in the proportion of 600 gallons to 10 cwt. of dry wood. The boiler is then screw down and fired, until it attains a pressure of 180lbs. to 200lbs. to the square inch, when the fire is drawn, and the boiler allowed to cool down. In about half-an-hour the lye is blown off, the top door is removed, and the contents scalded. The discharge-door is then screwed off, and the pulp drawn and washed with pure water in a poaching-engine. The fibre having been completely separated from the rosin and other matters, become easily pulped, whilst the latter are washed away. The boiler, which is tested by hydraulic power to 400 lbs. pressure to the square inch, is made of the strongest material and shape; the plates are of the very best quality, and the seams are all double rivetted. The furnace is in front at the bottom of the boiler, which is built upright on its seat, and there is a discharge branch in the rear. The flue goes round the boiler spirally to the top, and thus produces an equal heat at every part. A simple internal arrangement secures a rapid circulation of the lyes through the material, and effectually prevents the wood from being charred. The pulp produced is stated to be far superior in length and firmness of fibre to any wood pulp yet known, and the first cost and the expense of working are considerably less than those of any other apparatus in use. When the washing process is concluded, the wood is left in the condition of washed or unbleached pulp, of the value of £15 per ton, as per table given below. The whole plant required for producing about 10 tons of this pulp per week can be erected at a cost of £1,200, and worked by four men of very ordinary skill.

It is said that at some paper-mills in Scotland, where they purchase their pulp in a state of complete preparation for the mill, they have been paying £16 10s. per ton for the pulp of esparto grass, containing 50 per cent. of moisture, so that it must take two tons of this pulp to make one ton of paper, at a total cost of £33, and this therefore shows a profit of 100 per cent. to the manufacturers of wood pulp. It is further suggested that the erection of a recovery of waste furnace, to evaporate the soda from the lye, after the pulp has been boiled in it, will ensure a saving of 50 per cent. in the cost of the caustic soda. A considerable number of the Scotch paper-makers are setting up the necessary apparatus for substituting wood for esparto grass, in view of the greater advantages the former is found to secure. Mr. John M'Nicol, of Glasgow, is the agent.

MATERIALS AND COST IN THE PRODUCTION OF WOOD PULP, EQUAL TO ONE TON OF PAPER READY FOR PASSING THROUGH THE PAPER-MILL :—

	£	s.	d.
43 cwt. of wood, at 30s. per ton	3	4	6
Caustic soda, for boiling the above, at 14s. per cwt., and 28 lbs. per cwt. of wood	7	10	6
Bleaching liquor	3	0	0
Labour of cutting wood	0	4	0
Fuel, 15 cwt. coal, at 8s. per ton	0	6	0
Labour of boiling, washing, and bleaching	1	0	0
Total	15	5	0

Specimens of the pulp may be seen by members at the House of the Society.

REVIEWS AND NOTICES OF NEW BOOKS.

Switches and Crossings. By William Donaldson, M.A., A.I.C.E. London: E. & F. H. Spon, Charing Cross.

This very complete work is for the purpose of giving all the necessary information that may possibly be required for designing and laying down switches and crossings upon railways. It is well known that in some places, such as the principal stations of main lines, work of this kind becomes very complicated, as it is frequently necessary to arrange the various crossings in as short a space as practicable. By the use of symbols for the various main and branch lines, the meanings of which are adhered to throughout the work, the explanation of this subject is very much simplified. Another practical difficulty, viz.: that it is generally impossible in the case of switches to carry out the theoretical curve in consequence of the excessive length which would then be necessary, has been overcome by fixing a "limit of deviation" from the correct curvature. After investigating the theory, a series of rules are given for the guidance of practical men, which from their comprehensiveness and freedom from mathematical formulae should be of great value to foremen platelayers. The engravings accompanying the treatise illustrate very completely the various cases which are investigated throughout the work.

A Treatise on the Application of Iron to the Construction of Bridges, Girders, Roofs, &c. By Francis Campin, C.E. London: Lockwood & Co., Stationers' Hall Court, London, 1871.

As the author of this treatise is a well-known practical man, it might be expected that the work would be at least worthy of careful attention. We scarcely anticipated, however, to find in such a small work so large an amount of really useful instruction. The author says, on the title page, that the work is especially designed for the use of students and mechanics, and doubtless this treatise would be of great value to such persons, but we question whether it would not be equally valuable to more matured engineers. For calculating the strength and also the weight of an iron structure the rules given, appear to be very simple and correct, and as no mathematical formulæ are used, they are within the comprehension of any ordinarily educated man. After reading the work we could have wished that it had been carried further, but as far as it goes it appears to be remarkably accurate and well written.

The Workman's Manual of Engineering Drawing. By John Maxton. London: Lockwood & Co., Stationers' Hall Court, 1871.

This is a very useful little work for mechanics, or those who have yet to acquire the various "notions" necessary to mechanical drawing, and it is consequently designed principally for the use of the "working engineer," who it is presumed has not had the advantage of instruction in the drawing office. Although the description of instruments and pencils there recommended, together with some of the minor operations respecting preparing the paper for drawing upon, are not such as we should prefer, it is evident that the treatise is written by a thoroughly practical man, and perhaps the very details to which we object might be of service to those who know no better. The instructions for setting out work, so far as they go, appear to be correct, but we should have wished to have seen in a work professing to instruct engineers a few more engineering examples for their imitation.

Lighthouse Illumination. By Thomas Stevenson, F.R.S.E., M.I.C.E. 2nd edition. Edinburg: Adam & Charles Black, 1871.

We have received a copy of the second edition of this very valuable work. As we have already not only reviewed the first edition, but availed ourselves of the privilege of transfering a portion relating to lighthouse illumination to the pages of The Artizan, it is difficult to add fresh words of commendation to such an excellent work; we must, therefore, be content to say that descriptions of all the later improvements have been embodied in the present edition. We may also be allowed to add that as an instructive work upon this subject we do not know its equal.

NOTES AND NOVELTIES.

MISCELLANEOUS.

We regret to learn that Dr. Carpenter's engagements will prevent his devoting himself to the work of deep-sea sounding, which he has so ably begun. We are glad, however, to hear that the Government is prepared to entertain favourably the request for the expedition of deep-sea exploration.

The whole of the gas for the city of London will shortly be supplied from the new gasworks at Beckton, and arrangements have been made that the appointment of examiner of this gas shall alternately be exercised by the Board of Works and the Corporation, the latter body to have the first nomination.

The foundation-stone of a new lighthouse has lately been laid at the Longships, off Land's End, by the resident engineer, Mr. M. Bearley. The stone weighed two tons, and is of French granite. It forms part of the lowest course of the tower, and is fitted into the rock. The lighthouse will be 116ft. above high water, and the light will be seen at a distance of sixteen miles.

The British Consul-General at Havana, Mr. Graham Dunlop, in his report for the year 1870-71, observes that it is thought that the papermakers of England should give some attention to the enormous quantities of fibrous tropical plants and trees which abound in Cuba. Successful experiments have been made by local papermakers on the fibre of the bamboo cane and on some of the creeping parasitic plants indigenous to Cuba. The Consul hears that attention is being given in Jamaica to the preparation of the fibre of the bamboo for the papermakers in America. This beautiful plant, or rather tree, grows abundantly in Cuba, and could be purchased and crushed at very cheap rates. It is said to excel for paper all the fibrous grasses of late used by our papermakers, and to mix easily with the linen rag pulp and other more ordinary materials.

MILITARY ENGINEERING.

The Russian fortifications at the railway stations of Radziwillow and Wolocysk are being rapidly proceeded with. The former is the last station towards the frontier of the Brest-Berdyczew-Radziwillower Railway. Both stations are of the utmost strategical importance, and have an uninterrupted communication with the Galician nest of railways. In the neighbourhood of Radziwillow Imperial engineers have been engaged for weeks in surveying and levelling, and after their plans a citadel with detached forts will be erected in the neighbourhood of the station for its further protection. The fortifications are to be completed within three years. A similar course has been adopted at Wolocysk. Other fortifications are already nearly completed, notably in the extension of the works at Lithuanian Brest and Kiew, and their strengthening by detached forts.

STEAMSHIPPING.

Arrangements have been made to open a line of steamers between the Tyne, Bergen, and New York. The first steamer for the line was launched a short time ago from the building yard of Messrs. J. Wigham, Richardson, and Co., Walker-on-Tyne and she is named the *St. Olaf*. She is 300ft, long and 900 effective H.P. She will sail north about by Scotland, and will call at Bergen, in Norway, upon each voyage, and take from 500 to 600 emigrants for New York, for whom she has accomodation.

SHIPBUILDING.

We understand that Messrs. Caird and Co., Greenock, have been instructed by Messrs. Inman to build for their Liverpool and American line a screw steamer of about 480ft. over all, about 430ft. keel and fore rake, 44ft. breadth of beam, 36ft. depth of hold, while he gross tonnage of the ship will be about 4,800 tons. The vessel is to be supplied with the builders' compound engines of 750-H.P. She will be full ship-rigged, and it is expected that she will attain a speed of 16 knots an hour. The steamer will be the largest merchant vessel afloat, excepting the *Great Eastern*, the latter being about 130ft. longer than the proposed new steamer. Messrs. Caird, we understand, have been exclusively selected by the Inman Company to build this vessel, and as *carte blanche* has been given the builders to produce one of the best ships possible, it is anticipated that the steamer will command considerable attention.

LAUNCHES.

The new steamship *City of London*, built for the Aberdeen and London Steam Navigation Company, which was launched a few weeks ago from the building-yard of Messrs. John Elder and Co., at Glasgow, arrived in the Aberdeen harbour on the 19th ult. Judging from the results of her trial trip, and her passage from the Clyde to Aberdeen, she is, without doubt, the finest vessel of her class that ever entered the harbour, and will prove no unworthy successor to the old *City*, which has lately been disposed of. While passengers will be carried to and from London in a tide less time than formerly, the company will save upwards of a hundred tons of coal on each double journey. The *Ban-Righ*, sister ship to the new *City of London*, makes the passage to London in 36 hours, whereas the old *City* took 46 hours; and while the latter required 190 tons of coal for the double passage, the former only requires 70 ton. Passengers may experience the additional comfort when leaving in the morning, of being only one night on the sea. These results are due mainly to the adoption of the compound principle of engines. These engines have two cylinders—the one acting as an auxiliary, and producing additional motive power by reutilising the steam from the other. Her length in 241 9-10ths feet, her breadth 30 5-10ths, her depth of hold 16 7-10ths, and her tonnage 977 tons. Her engines are 275-H.P. nominal, and over 1,300 of actual power. She has 70 berths for first-class and 50 berths for second-class passengers, and stalls for 170 head of cattle. From the main-deck to the forecastle the whole length of the vessel can be traversed as on one deck, and it will add to the cleanliness of the saloon cabin that it is entered from the quarter-deck instead of from the main-deck. It is worthy of note also that an important improvement has been made upon the propeller, whereby, instead of having by a tedious process to unship the whole propeller when an accident occurs, the broken blade can be unscrewed, and a new one screwed on in its place. The trial trip of the *City of London* was most satisfactory. According to the specification, she had to steam thirteen knots in sixty minutes, but she accomplished the distance and a quarter of a mile more within the time, and upon the contract consumpt of coal. A still more satisfactory test of the vessel's powers was afforded on the passage from the Clyde to Aberdeen. The distance between Greenock and Aberdeen—554 miles—was accomplished without one stopping, in thirty-nine hours, being an average speed of fourteen miles an hour; and the quality of her engines was most satisfactorily tested by the fact that they made during all that time exactly a stroke a second without any of their parts being heated.

On the morning of July 31st the London and Glasgow Shipbuilding Company (Limited) launched from their yard at Govan a handsome little screw steamer for the river carrying trade, named the *Penguin*. Her owners are Messrs. James Steel and Son, of Glasgow, and Steel and M'Caskill, of Greenock and 'Derry, who are building three screw-steamers named *Albatross*, *Ospray*, and *Seagull*, for their 'Derry connection, and the *Heron* for the Clyde trade.

On the afternoon of the 5th ult. Messrs. Thomas Wingate and Co. launched from their building yard at Whiteinch two iron screw hopper barges of 250 tons, B.M., each, and 30-H.P. nominal. They are intended to be employed in carrying the dredgings from the machine launched some time ago by the Messrs. Wingate, for the improvement of the navigation of the Rio Sao Goncalo, Brazil, which is being carried out by Messrs. Storry and Smith, C.E., of Glasgow. They are named respectively the *Portador* and *Coadjutor*. Messrs. Wingate and Co. have a large quantity of dredging plant on hand, and are presently engaged shipping in pieces two small dredgers for the Ecuador Government; the largest is of 15-H.P., and the smaller one is fitted to be driven by horses or mules working on board.

A large new iron dredger, built and engined by Messrs. W. Simons and Co., was launched on the 5th ult. from the London Works, Renfrew. It is the property of the River Tees Conservancy, Stockton, and has been constructed to the order of Mr. Fowler, their engineer. It is 140ft. long over all, 25ft. broad, and 20ft. high, and is designed with double bucket girders, so as to have the properties of two dredgers in one hull. It is fitted with every improvement introduced by the builders, and all its movements, whether hoisting, lowering, dredging, going ahead, astern, or sideways, are executed and controlled by steam-power; and its massive proportions may be judged by the fact that in it are combined over 10,000 pieces iron, brass, and steel, each different from the other.

On the 4th ult. there was launched from the ship-yard of Messrs. James and George Thomson, at Govan, a beautifully-modelled screw steamship, of 2,000 tons and 250 H.P., intended to be the pioneer of a line of first-class steamships to China, *via* Suez Canal, sailing from London, under the management of Messrs. Thomas Skinner and Co., being a continuation of their well-known line of *Castle* ships. The *Gordon Castle* will be fitted with every improvement that experience may suggest for the comfort of passengers and the efficient working of the ship, including the most improved arrangements for ventilation to holds and cabins. Messrs. Thomson have on hand three additional steamships for Messrs. Skinner's Castle Line, which is intended to form a fleet sufficiently numerous to meet the requirements of their extensive and long-established Eastern trade.

On the 16th ult. there was launched from the building yard of Messrs. Hall, Russel and Co., iron shipbuilders, Footdee, Aberdeen, a handsome iron steamer, named the *Hai Loong*, of the following dimensions:—Length 160ft., beam 24ft., depth 16·6, with a register of 480 tons. The vessel has been built to the order of James Morrison and Co., London, and is intended for the trade between Foochoo and Amoy. Captain Farron is to be the commander.

Messrs. Cunliffe and Dunlop launched, on the 18th ult., from their Inch Shipbuilding and Engineering Works, an iron screw steamer for the British and African Steam Navigation Co., of the following dimensions:—Length, 180ft.; breadth of beam, 25ft.; depth of hold, 11ft.; tonnage, 550 tons B.M.; and to be fitted by the builders with a pair of compound engines of 70 H.P. nominal. As the vessel left the ways she was named the *Kwara* by Miss Wilson.

On the 16th ult. Messrs. John Elder and Co. launched from their shipbuilding yard a Fairfield, Govan, an iron screw steamship of 3,000 tons gross register and 400 tons H.P. nominal, for the Stoomvaart Nederland Co. The vessel has been designed and constructed for that Company's service between Amsterdam and Java *viâ* the Suez Canal, and is of the following dimensions:—Length between perpendiculars, 350ft.; breadth, 39ft.; depth moulded, 31ft. In the equipment of the ship the latest improvements have been introduced, her internal arrangements, state rooms, saloon, &c., being fitted up and furnished in the highest style of elegance and comfort, having accommodation for 100 first-class, 50 second, and a number of third-class passengers. She has great carrying capacity, with light draught of water. The engines, which are being supplied by the same firm, are upon their compound principle, with all the latest improvements. The ceremony of naming her the *Prins Hendrik* was gracefully performed by Mrs. Elder. The *Prins Hendrik* is similar in construction to the *Wilhelm III.* and *Prins Van Orange*, launched by the same firm, and for the same Company, this year, with the exception that she is 20ft. longer than those vessels. The firm have still another vessel on the stocks for the above-named Company.

The screw steamer *Scindia* was launched from the yard of Messrs. Oswald and Co., Pallion, Sunderland, on Thursday, the 17th ult. She is built for Messrs. C. M. Norwood and Co., of Hull, for their Red Cross Line of steamers between London and Calcutta, and is 2,150 tons register. Her dimensions are—length 300ft. between perpendiculars, 310ft. over all, 35ft. beam, and 25ft. deep. She is built with full poop and topgallant forecastle and hurricane deck-house, and fitted with first-class accommodation for 30 passengers, every care being taken to give a thorough ventilation for the Indian climate. The vessel as she left the stocks was named the *Scindia* by Mrs. John F. Norwood, of Hull, the wife of the principal owner, in the presence of a large number of visitors. This is the largest steamer yet launched on the Wear, and the builders have on the stocks, to be launched in about six weeks, a sister vessel. Both steamers are to be fitted with compound surface-condensing engines of 200 nominal H.P. by the builders.

At Port Glasgow, on the 19th ult., the following launches took place:—The *Redgauntlet*, s.s., 260ft. long, gross tonnage, 1,460, built by Messrs. Blackwood and Gordon for George Gibson and Co.'s (Leith) Eastern trade. She was named by Miss Crawford, of Glasgow.—Messrs. William Hamilton and Co. launched the *Precursor* 1,000 tons, and *St. Helen's*, 1,150, screw-steamers, owned in London. These are the last launches from the present premises of the firm, they having removed to the yard lately occupied by Messrs. McCulloch, Paterson, and Co.—Messrs. John Reid and Co. launched a ship of 1,200 tons, named the *Kilkerran*, of like proportions to the lately built *Colmonell*, for Messrs. John Kerr and Co.'s (Greenock) East India trade.

On the 18th ult. Messrs. Denny Bros. launched an iron screw steamship of 3,000 tons register, the property of the Royal Mail Steam Packet Co., which will be fitted with machinery on compound direct-acting principle of 500 H.P. nominal, by Messrs. Denny and Co. The usual ceremony of christening was performed by Miss Bevis, daughter of Capt. Bevis, superintendent for the owners. The vessel was named *Boyne*.

On the 17th ult. Messrs. Barclay, Curle, and Co. launched an iron three-decked screw-steamer, of 1,550 tons register, for Messrs. William Thomson and Co., Leith. The vessel will be fitted with compound engines supplied by the builders. She was named the *Benledi*, the ceremony being performed by Miss Buchanan, daughter of the commander of the steamer.

TRIAL TRIPS.

The Peninsular and Oriental Company's new screw-steamer *Mirzapore*, built and designed by Messrs. Caird and Co., Greenock, proceeded down the Firth on the 19th ult., on a preliminary trip, previous to leaving for Southampton, where she will embark her passengers, &c., before proceeding on her maiden voyage to India and China *via* the Suez Canal. The *Mirzapore* is a very finely modelled spar-decked three masted, schooner rigged full power steamer, of upwards of 3,000 tons. She is 400ft. long over all, 42ft. breadth of beam, and 36ft. depth of hold, and is propelled by compound engines of 600 H.P. She has accommodation for 200 first class and 50 second class passengers, besides accommodation for the large staff of officers, crew, &c. The *Mirzapore* is in every essential respect similar to the *Australia* and *Khedive*, recently constructed by Messrs. Caird and Co. for the Peninsular and Oriental Co. During the day the engines worked with great smoothness, and general satisfaction was expressed at the result of the trial.

The *Woodlark*, 3, 160-H.P., double screw steamer, was on the morning of the 28th ult., taken to the measured mile, Maplin Sands, for the purpose of making the official speed trials of her engines. The trials were carried out under the direction of the officials of the Steam Reserve, the vessel being in charge of Commander Brownrigg. On reaching the Maplin Sands six runs were made at full boiler power, when the mean speed attained was 10·77 knots per hour, mean pressure of steam in boilers 27 lbs., vacuum in condensers 25in., mean pressure in cylinders 19 lbs., mean number of revolutions per minute 118. The screws are Griffith's propellers, with a diameter of 8ft. 6in., and each set at a pitch, of 12ft. The mean draught of the vessel was 9ft. 7in. At half-boiler power the mean speed attained was 8·703 knots. The *Woodlark* steamed into harbour at the close of the trial

RAILWAYS.

The new spur line of the London, Brighton, and South Coast Company to Eastbourne has lately been officially opened for public traffic. The new line will greatly improve the train service between Eastbourne and London: all trains now run direct to and from Eastbourne. Additional trains for Eastbourne, St. Leonard's, and Hastings have been put on.

The doubling of the Belfast and Northern Counties line between Ballyclare and Dunadry stations is now in progress, and will be completed shortly. There has been added to the company's stock during the past six months twenty covered, ten open, and ten lime waggons. But even this number has been found insufficient, and to meet the requirements of the traffic twenty-five more waggons have been ordered. Two passenger vans have also been added to the stock. The Londonderry and Coleraine Railway Bill for the sale of the line to this Company has passed both Houses, and only awaits the Royal assent; when this is obtained, the necessary steps for taking over the line will be carried out. The capital account shows that £1,166,241 has been expended, leaving a balance against the account of £7,928.

An important link in the communication between London and places in the Isle of Wight beyond Ryde has been supplied by the completion of the short length of line between the railway station and pier at Ryde, which was opened for traffic last month. Sandown, Shanklin, and Ventnor passengers will, with their luggage, be now conveyed to and from the boats at Ryde Pier without having to change into the omnibuses for the journey through the town between the pier and railway station at Ryde. This will be a great convenience, and save time in the through service between the Isle of Wight and Victoria, London Bridge, Waterloo, &c.

The Ohio and Mississippi Railway, which runs from Cincinnati to St. Louis, having passed under new auspices, it became necessary to change the gauge from 6ft. width to 4ft. 9in. The line is about 300 miles long, and, in order not to interfere with the traffic, Sunday was selected as the day to make the change. All the available force of the line was set to work, beginning at daybreak; the rails on the entire length were taken up and replaced on the narrower gauge, and at eleven o'clock a.m. all the working parties had completed their labour, and the new line was in running order. Next day trains began running on the narrow gauge. This remarkable and somewhat superfluous work, extending over 300 miles of line, was performed in about seven hours.

TRAMWAYS.

The North Metropolitan Tramway Company have extended their line as far as Islington-green, and are making active progress in their further extension to Highgate, the rails having been laid down for a considerable distance along the Liverpool-road, and also in the Holloway-road.

DOCKS, HARBOURS, BRIDGES.

A very powerful steam crane is now being erected at the Chatham Dockyard Extension Docks, intended to lift the most ponderous articles ever likely to be landed there. It will be tested to lift 100 tons, while there is no crane now at the dockyard constructed to raise above 25 tons.

The work of rebuilding the docks and piers of New York city, under the comprehensive plan framed by General M'Clellan, has begun near the battery at the southern end of the city on the Hudson river side. The plan involves great labour and expense, and will take many years to complete.

The *Courier du Bas Rhin* states that at Berlin the execution of a canal to unite the Baltic and the North Sea is now under more serious consideration than ever. "The cutting," says that journal, "across a plateau two or three miles wide, and of which the highest elevation is not more than 68ft., cannot present any serious difficulties."

A new work has recently been recommenced after several unforeseen delays. This is the Albert bridge at Chelsea, which is to be constructed upon Mr. Ordish's rigid suspension principle, as carried out by him over the Moldau at Prague. The bridge will start from the site of the Cadogan Pier at Chelsea and terminate on the opposite shore of the river at the foot of Prince Albert-road. An important line of direct communication will thus be opened up between Chelsea and the fast rising town of New Battersea. The bridge will be ornamental in design and of a total length of 710ft., the roadway being 40ft. wide including the two pathways. There will be a centre span of 155ft. each. The foundations and peirs will consist of castiron cylinders, and the towers, which will rest upon them, will be of ornamental cast-iron. It is expected that the bridge will be finished about the middle of next year.

An important improvement in the navigation of the Lakes, useful equally to the Canadians and the Americans, has recently been opened to commerce. Formerly the navigation of Lake St. Clair was impeded by the circumstance that the waters of the St. Clair river, flowing from Lake Huron, poured into it through several channels, their greatest depth being 16ft. The channel generally used was narrow and crooked, with a depth averaging not over 15ft., and was very difficult to navigate even in daylight. It had been several times dredged; but this was expensive, and only a temporary remedy. Several years ago General Thomas J. Cram, United States' Army, suggested the plan of constructing a ship canal, beginning near the mouth of St. Clair river, by which vessels could be passed across the lake in a direct line to the entrance of Detroit River, which flows into Lake Erie. This canal was begun in 18·8, and has just been completed at a cost of about 428,000 dols., having on the 24th of July been formally accepted by the United States' Inspector. It consists of two dykes 7,221ft. long each, 40ft. wide, and made of clay and sand enclosed in timber frames. At each end of the western dyke, which is towards the Michigan shore, lighthouses are being erected. The dykes are covered with willow trees, set out in ornamental figures. The canal, including bays at each end, which extend beyond the dykes, is 8,421ft. long, the width at the bottom of the entrance to each bay being 416ft., while between the dykes the bottom of the canal is 300ft wide. The dykes on either hand are raised 5ft. above the water surface, while the piles inclosing them are driven 12ft, below the bottom, about 7ft. being solid clay. The entire work is constructed in a substantial manner, the canal having sufficient depth to pass vessels drawing 15ft., and a constant stream of craft of all characters is now passing through.

APPLIED CHEMISTRY.

M. Wurtz has announced to the French Academy of Sciences that a young chemist in his laboratory has succeeded in transforming lactose, or the uncrystallisable sugar of milk, into dulcose or dulcine, the sugar of mannite, which may easily be obtained in very beautiful crystals by the successive reaction of hydrochloric acid and sodium-amalgam.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	76	0	0	78	0	0
Tough cake and tile do.	74	0	0	76	0	0
Sheathing and sheets do.	76	0	0	80	0	0
Bolts do.	79	0	0	80	0	0
Bottoms do.	80	0	0	83	0	0
Old do.	60	0	0	,,	,,	,,
Burra Burra do.	76	0	0	77	0	0
Wire, per lb.	0	0	9¾	0	0	10
Tubes do.	0	0	10½	0	0	10¾
BRASS.						
Sheets, per lb.	0	0	8	0	0	8¾
Wire do.	0	0	7¾	,,	,,	,,
Tubes do.	0	0	8	0	0	10½
Yellow metal sheathing do.	0	0	6¾	0	0	7½
Sheets do.	0	0	6½	0	0	7
SPELTER.						
Foreign on the spot, per ton.	18	7	6	18	10	0
Do. to arrive.	18	5	0	18	7	6
ZINC.						
In sheets, per ton	24	10	0	,,	,,	,,
TIN.						
English blocks, per ton.	136	0	0	,,	,,	,,
Do. bars (in barrels) do.	137	0	0	,,	,,	,,
Do. refined do.	137	0	0	138	0	0
Banca do.	135	0	0	136	0	0
Straits do.	130	0	0	131	10	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	9	6	1	10	6
IX. do. 1st quality do.	1	16	0	1	17	6
IC. do. 2nd quality do.	1	7	6	1	8	0
IX. do. 2nd quality do.	1	13	6	1	14	0
IC. Coke do.	1	5	0	1	7	0
IX. do. do.	1	11	0	1	13	0
Canada plates, per ton	13	10	0	15	0	0
Do. at works do.	13	10	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	7	12	6	7	15	0
Do. to arrive do.	7	10	0	,,	,,	,,
Nail rods do.	7	12	6	8	0	0
Do. Stafford in London do.	8	5	0	,,	,,	,,
Bars do. do.	8	10	0	9	2	6
Hoops do. do.	9	5	0	9	10	0
Bars do. at works do.	7	15	0	8	0	0
Hoops do. do.	8	5	0	8	12	6
Sheets, single, do.	10	0	0	,,	,,	,,
Pig No. 1 in Wales do.	4	0	0	4	15	0
Refined metal do.	4	0	0	5	0	6
Bars, common, do.	6	15	0	7	0	0
Do. mrch. Tyne or Tees do.	7	10	0	,,	,,	,,
Do. railway, in Wales, do.	6	15	0	7	0	0
Do. Swedish in London do.	10	2	6	,,	,,	,,
To arrive do.	9	17	6	,,	,,	,,
Pig No. 1 in Clyde do.	3	3	0	3	10	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. Nos. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	5	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	16	0	0
English spring do.	17	0	0	23	0	0
Quicksilver, per bottle	9	10	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	0	0	,,	,,	,,
Ditto L.B. do.	18	2	6	,,	,,	,,
Do. W.B. do.	19	5	0	,,	,,	,,
Do. sheet, do.	18	5	0	18	10	0
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	20	5	0	,,	,,	,,
Spanish do.	17	10	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

DATED JULY 12th, 1871.

1813 F. S. Cole—Hydraulic machine
1814. T. Harrison—Drills
1815 A. H. Brandon—Mattresses
1816 E. O'Brien—Turning over music
1817 J. C. Cellars—Blacking
1818 W. Walker—Coverings for ricks
1819 T. D. T. Sparrow—Darning socks
1820 G. F. Harrington—Propelling ships
1821 S. C. Lister—Looms
1822 L. Perkins—Steam engines
1823 J. Walker—Attaching knobs to spindles
1824 J. Wall—Fastenings for shirt studs
1825 W. E. Newton—Printing
1826 G. and T. Shaw—Treatment of fibres
1827 W. B. Moffatt and G. M. Henley—Burning bricks
1828 J., W., and F. W. Edmondson—Etching cylinders
1829 J. J. Franks—Mode of flushing
1830 W. R. Lake—Knitting machines

DATED JULY 13th, 1871.

1831 T. E. Tallent—Working signals
1832 J. M. Joannides—Seed protector
1833 J. and T. Torrance—Bleaching fibre
1834 A. Tessier—Raw soda
1835 R. Saunders—Shoes for horses
1836 W. Bayliss—Fencing
1837 W. G. Valentin—Peroxidation of oxide of manganese
1838 J. Brown—Protecting the bottoms of ships

DATED JULY 14th, 1871.

1839 W. Riddell—Paper pulp
1840 E. E. Collins—Treating skutch
1841 H. Eaton—Coke ovens
1842 J. R. Croskey—Pavements, &c.
1843 J. Townsend—Lubricating oils
1844 H. and W. Sutcliffe—Forming pipes
1845 F. P. Preston, J. T. Prestige, E. J. Preston, and W. A. Prestige—Waste-water preventer taps
1846 A. M. Clark—Medicinal compounds
1847 F. N. Target—Dry closets
1848 J. Holding—Looms
1849 H. Stead—Musical instruments
1850 W. E. Newton—Condensers
1851 J. T. Way—Phosphate of lime
1852 J. H. Johnson—Spectacles

DATED JULY 15th, 1871.

1853 J. H. Johnson—Extracting resinous matter from wood, &c.
1854 J. Hargreaves and T. Robinson—Absorption of gases by solids, &c.
1855 W. Burslem—Pickers
1856 G. Mold and W. G. Mold—Hand hoe
1857 F. J. Evans—Gas
1858 E. A. Heath—Cuspadores

DATED JULY 17th, 1871.

1859 A. G. Brown—Disinfecting water-closets, &c.
1860 T. Bassett—Compass correctors
1861 J. H. and E. C. Pratt—Buttons
1862 W. Cadman—Blinds
1863 G. Demailly—Separating the fibrous matter of textile plants
1864 W. E. Gedge—Joining bricks, &c.
1865 I., B., and H. Smith, and C. Bradley—Combing silk
1866 J. Aston—Firearms
1867 A. M. Clark—Pen holders

DATED JULY 18th, 1871.

1868 A. Zipser—Anti-incrustator
1869 H. Wilkerson—Fastening trucks
1870 R. Eastman—Castors
1871 T. Helliwell—Cross weaving
1872 T. Cartwright—Preventing injury to steam engines
1873 F. Hurd—Chopping sugar
1874 F. Wilkinson—Treatment of cotton
1875 J. Kuttner—Looms
1876 H. Vaughan—Escape valve
1877 B. J. B. Mills, Axles, &c.
1878 R. Turnbull—Floating docks

DATED JULY 19th, 1871.

1879 J. Casthelaz and C. Depoully—Size
1880 J. M. Goodall—Cutting cards
1881 A. H. Stott—Fireproof flooring
1882 B. J. B. Mills—Wheels, &c.
1883 B. J. B. Mills—Ventilating vessels
1884 J. Wray—Reaping machines
1885 G. Bowyer—Tramways
1886 R. Aitken—Breakwaters
1887 J. McGlashan—Testing yarn
1888 J. Parkins—Regulating the width of black borders on cards
1889 H. E. Newton—Lounging chair
1890 T. Morris—Fog signal
1891 C. Andrews—Drawing off beer
1892 J. Douglas—Heating buildings
1893 W. Morgan—Derrick cranes

DATED JULY 20th, 1871.

1894 C. D. Abel—Ventilating hat
1895 B. Hunt—Ink holders
1896 A. K. Irvine—Safe combustion of gas
1897 F. Fenton—Utilisation of sewage
1898 J. M. Rainforth—Ploughs
1899 S. Sanderson—Extinguishing fire
1900 W. Harrison—Fixing door handles
1901 S. S. Robson and G. Rerwick—Preserving metallic surfaces
1902 V. Werotte—Evaporating apparatus
1903 W. R. Lake—Shoe heels
1904 C. Pritchard—Land scarifiers
1905 W. R. Norminton—Self-escapement hopper
1906 W. N. Hutchinson—Obtaining infusions from coffee berries
1907 W. R. Lake—Automatic compensating mechanism

DATED JULY 21st, 1871.

1908 H. Deacon—Sulphate of soda
1909 W. E. Gedge—Hosiery frames
1910 W. E. Gedge—Ploughing
1911 P. Abraham—Separating molasses from sugar
1912 C. Wilson—Stop motion
1913 J. Stodart—Digging potatoes
1914 A. and R. de Bergue—Veneer cutting machines
1915 R. Bright—Lamps
1916 R. Herring—Printing telegraps
1917 J. Fordred—Treating yeast
1918 W. Hunt—Chlorate of potash
1919 R. Warner and J. Brooke—Pumps
1920 J. Hargreaves and T. Robinson—Sulphuric acid
1921 S. Rogers—Motive power, &c.
1922 R. Dempster—Hasp
1923 J. Hargreaves and T. Robinson—Treating metallic ores
1924 S. Rogers—Couplings

DATED JULY 22nd, 1871.

1925 J. King—Lock
1926 S. Rogers—Raising window sashes
1927 S. Rogers—Brakes
1928 J. Hargreaves and T. Robinson—Sulphates
1929 W. G. Rothwell—Obtaining motive power
1930 G. Sinclair—Boilers
1931 W. Hughes—Sugar mills
1932 H. J. Madge—Utilising the spent pickle of the tin plate
1933 J. M. Clements—Needle setter
1934 G. Qurin and J. Essl—Lamps
1935 B. Hunt—Egg beater
1936 J. Weir—Steam engines
1937 F. P. Preston, J. T. Prestige, E. J. Preston, and W. A. Prestige—Waste water preventer cisterns
1938 J. L. Norton—Paving
1939 C. W. Curtis—Gunpowder
1940 I. Brown—Irrigation of land

DATED JULY 24th, 1871.

1941 W. Isherwood—Heating railway carriages
1942 J. Lewtas—Lamps
1943 R. C. Munson—Opening envelopes
1944 W. Sumner and E. H. Waldenström—Boring
1945 E. G. Brewer—Knitting machinery
1946 D. W. Fessey—Connecting loose heels to boots
DATED JUNE 25th, 1871.

1947 E. G. Brewer—Belts
1948 S. Mason and A. Dawson—Combing machine
1949 R. M. Marchant—Steam engines
1950 C. Wilson—Trucks
1951 J. C. G. du Vallon—Punches
1952 E. Mirchin—Steam boilers
1953 J. C. Haddan—Permanent way, &c.
1954 A. Budenberg—Reversing gear
1955 J. D. Morrison—Purifying water
1956 R. S. Craig—Soup

DATED JULY 26th, 1871.

1957 J. Brodie—Reclaiming land
1958 G. B. Galloway—Obtaining motive power
1959 C. W. Siemens—Smelting
1960 J. C. Bowser—Printing
1961 J. M. Jones—Dressing hides
1962 D. Davidson—Steam boilers
1963 W. Love—Pulp
1964 W. L. Lavers—Reaping machines

DATED JULY 27th, 1871.

1965 W. R. Lake—Vessels for converting steel, &c.
1966 T. J. Smith—Combing wool
1967 P. A. Dormoy—Steel, &c.
1968 H. Grubb—Lenses
1969 E. Taylor—Treatment of human excreta
1970 W. L. Grauville—Bottle-corking machine
1971 R. Stokoe—Desks
1972 G. Warsop—Perambulators
1973 L. Hill—Tramways
1974 J. Sprague—Drilling machines
1975 G. Chrystal—Steam boilers
1976 A. M. Clark—Sewing machines
1977 L. B. Bertram—Plug for tobacco pipes
1978 W. Lomberg—Soap
1979 E. Duley and E. Marriott—Ordnance
1980 J. Turney—Skudding skins

DATED JULY 28th, 1871.

1981 H. M. Marsden—Shears
1982 T. Thomson—Treating ores
1983 R. Hughes—Sweeping roads
1984 B. Pechenart and L. Miette—Nails
1985 B. H. Paul—Asphaltic material
1986 J. Beard—Carding engines
1987 J. R. Wood and W. Wilde—Joints
1988 A. Virollet—Water feeding apparatus
1989 S. Bremner—Printing machines
1990 D. Shive—Detecting the absence of watchmen
1991 J. Grantham—Steam carriages
1992 J. Revell—Lubricating spindles
1993 J. Stephens—Ascertaining distances
1994 J. Broad—Treatment of tan

DATED JULY 29th, 1871.

1995 A. Littlebales—Lockets
1996 S. Townsend—Cleaning boots
1997 S. Whitworth—Shuttles
1998 E. O. W. Whitehouse—Instruments for electric telegraphs
1999 L. A. Keily and C. H. Tipple—Game of amusement
2000 J. E. Holmes—Cutting stone
2001 N. Clayton and J. Shuttleworth—Steam engines
2002 J. H. Johnson—Firearms
2003 C. B. Lane—Tramways

DATED JULY 31st, 1871.

2004 E. Johnson—Rifles, &c.
2005 A. Wehl—Damping rollers
2006 J. G. Tongue—Steam boilers
2007 A. M. Silber and F. White—Lighting
2008 W. Weldon—Obtaining sulphur, &c.
2009 J. Simpson—Saddle boilers
2010 J. Durand—Buttons
2011 P. Giffard—Pistons
2012 J. Blick—Untwisting hair
2013 J. E. Liardet—Cables, &c.
2014 E. L. Hayward—Pavement lights
2015 T. J. Smith—Cutting threads

DATED AUGUST 1st, 1871.

2016 D. Bate—Corn mill
2017 S. Hart—Carriages
2018 J. Edwards—Permanent way
2019 C. De Negri—Paper pulp
2020 W. E. Everitt—Tubes for boilers
2021 H. Armistead, T. Tunstill, and R. Tunstill—Looms
2022 R. Cornthwaite—Balling warps of cotton, &c.
2023 F. A. Armstrong—Combination game board
2024 C. Crockford—Production of the alkalies and their salts
2025 D. Hancock and C. Pearse—Production of lighting gas
2026 A. V. Newton—Handles of shovels
2027 J. Petrie—Steeping wool
2028 J. T. Way—Phosphates of soda
2029 A. M. Watkin—Relieving the slide valves of engines, &c.
2030 N. P. Stockwell—Sewing machines
2031 B. Hunt—Aërial navigation

DATED AUGUST 2nd, 1871.

2032 L. Klerity—Gravitating rope hores
2033 E. A. Chameroy—Regulating the pressure in delivery pipes
2034 A. Munro and W. B. Adamson—Cutting stone, &c.
2035 L. Stewart—Pens
2036 R. B. Sanson—Pressing garments
2037 B. Dobson and J. Macqueen—Preparing cotton, &c.
2038 G. L. Chaffer—Blowers
2039 C. Gordon—Firearms
2040 W. J. Curtis—Obtaining extracts
2041 T. B. Upfill—Joints for bedsteads
2042 T. Whitehead—Preparing cotton
2043 R. F. Fairlie—Railway carriages
2044 W. R. Lake—Railway vehicles

DATED AUGUST 3rd, 1871.

2045 G. F. James—Fuses
2046 G. D. Davis and W. Hopcraft—Working anchors
2047 J. Hosken and F. G. Fleury—Water waste preventers
2048 G. Thomas—Cleaning knives
2049 E. Hoskell—Alarum pump
2050 J. Darling—Lamps
2051 St. J. V. Day—Anchor
2052 A. E. Ragg—Weighing letters
2053 W. Pidding—Mechanism applicable to locomotion
2054 T. J. Smith—Obtaining motive power
2055 W. R. Lake—Sewing machines
2056 D. C. Knab—Treating refuse

DATED AUGUST 4th, 1871.

2057 E. J. W. Parnacott—Solidifying oils
2058 E. V. Neale—Stopping the extent of angular motion, &c.
2059 T. G. Knight—Barrel tilters
2060 W. Miller—Hydro-pneumatic engines
2061 U. F. A. Rosing—Cultivating land
2062 A. A. Croll—Meters
2063 G. Goldsmith and J. Dilkes—Heating by gas
2064 G. T. Bousfield—Refrigerative vessels
2065 R. Hodson—Signalling

DATED AUGUST 5th 1871.

2066 E. Roberts—Heating apartments
2067 W. Thomas—Tramway cars
2068 F. Kaiser—Ovens
2069 G. Weston—Cutting boot laces
2070 E. J. W. Parnacott—Waterproof sheets, &c.
2071 J. McHardy—Railway signals
2072 W. Clissold—Carding engines
2073 J. Dejey—Emerald cloth
2074 P. J. Ekman—Window sashes
2075 J. Marshall—Thrashing machines
2076 A. Barclay—Coking coal

DATED AUGUST 7th, 1871.

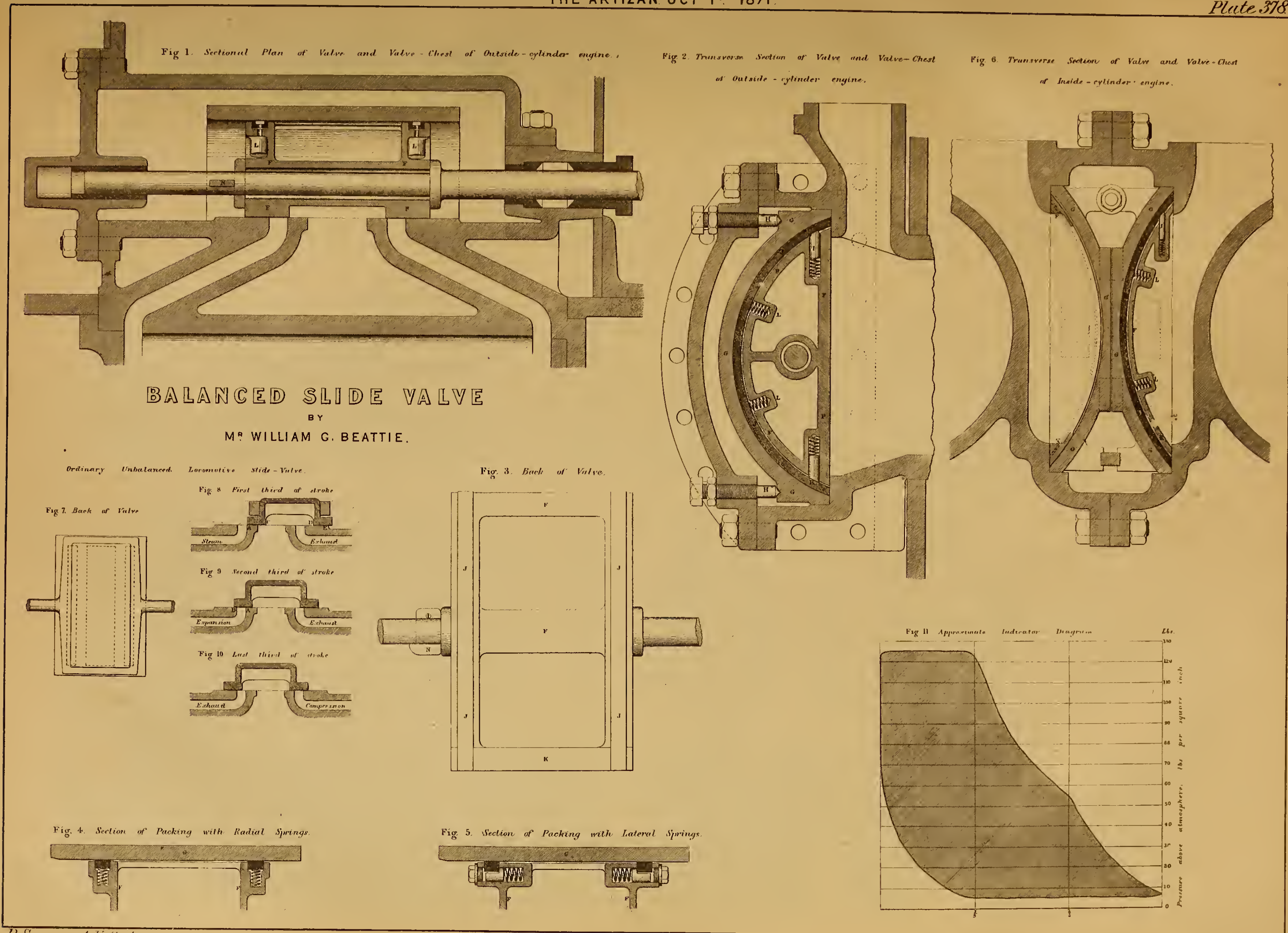
2077 T. Unsworth and E. Whalley—Self-stopping winding frame
2078 W. Allanson and J. Pearson—Fastenings for chains, &c.
2079 A. V. Newton—Belt fastening
2080 B. Tanner—Phosphoric acid
2081 J. H. Johnson—Utilising the gases from blast furnaces
2082 J. H. Johnson—Manufacture of beer
2083 W. H. Prossor and J. V. Slattery—Curing bacon
2084 H. Highton—Galvanic batteries

DATED AUGUST 8th, 1871.

2085 B. Turner—Hinges
2086 R. Scott—Treating oils
2087 A. McLachlan—Cutting verges
2088 W. Ferrie—Puddling furnaces
2089 S. Sharrock—Telegraph posts
2090 J. Duncan, J. A. R. Newlands, and B. E. R. Newlands—Treatment of saccharine solutions
2091 A. V. Newton—Governor
2092 W. R. Lake—Sand papering machines

DATED AUGUST 9th, 1871.

2093 H. W. Widmark—Waste water valves
2094 L. Guinotte—System of variable expansion, &c.
2095 H. A. Bonneville—Filling bottles
2096 H. A. Bonneville—Paving of roads
2097 E. Jones—Cartridges
2098 S. T. Dutton—Working the points of railways



BALANCED SLIDE VALVE

BY

Mr. WILLIAM G. BEATTIE.

Fig 1. Sectional Plan of Valve and Valve-Chest of Outside-cylinder engine.

Fig 2. Transverse Section of Valve and Valve-Chest of Outside-cylinder engine.

Fig 6. Transverse Section of Valve and Valve-Chest of Inside-cylinder engine.

Ordinary Unbalanced Locomotive Slide-Valve.

Fig 7. Back of Valve

Fig 8. First third of stroke

Fig 9. Second third of stroke

Fig 10. Last third of stroke

Fig. 3. Back of Valve.

Fig 11. Approximate Indicator Diagram

Fig. 4. Section of Packing with Radial Springs.

Fig 5. Section of Packing with Lateral Springs.

P. Simms, A.K.C. direx

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BALANCED SLIDE VALVES FOR LOCOMOTIVE ENGINES.

By Mr. William G. Beattie.

(Illustrated by Plate 378).

The ordinary slide-valve that is generally used in locomotives has the serious disadvantage that the pressure upon it when working is so heavy as to cause great wear of the rubbing faces of the valve and cylinder ports; and the force expended in overcoming this friction is a considerable loss of power, and involves serious wear of the valve gear, and difficulty in quickly altering or reversing the action of the valve.

An ordinary locomotive slide-valve is shown in Figs. 7 and 8, Plate 378, having 1 inch outside lap; and the area of this valve that is under pressure during the portion of the stroke in which steam admission takes place, which may be taken at one-third of the stroke, extends from the edge of the steam port at A to the end of the cylinder-port facing at E, being 10in. length by 17in. width of the valve over the flanges, or an area of 170 square inches under steam pressure, for an engine with 17in. cylinders. During the remaining two-thirds of the stroke after the steam port is closed, the whole area of the valve is under steam pressure, being $10\frac{1}{2}$in. length by 17in. width, or 178 sqnare inches area; and this gives an average throughout the stroke of 176 square inches area, which at 125lbs. per inch pressure of steam in the valve chest amounts to a total pressure upon the back of the valve of 22,000lbs.

From this pressure on the back of the valve has to be dedncted the pressure under the valve, exerted by the steam in the cylinder; and taking the exhaust to open at two-thirds of the stroke, this pressure under the valve will be in the first third of the stroke that of the exhaust steam only, acting on the area C D of the inside of the valve, Fig. 8. In the second third of the stroke, Fig. 9, there will be in addition the pressnre of the expanding steam within the cylinder acting upon the area of the steam port A B; and in the last third of the stroke, Fig. 10, there will be the pressure of the exhausting steam from the cylinder acting on the inside of the valve, with the addition of an average area of half the steam port, and also the pressure of the compression at the other end of the cylinder acting on the area of the other steam port. From the results of indicator diagrams taken with the same pressure of steam, 125lbs. per inch, at a speed of 20 miles per hour, these several pressures may be taken as follows, as shown in the approximate indicator diagram, Fig. 11. In the first and second thirds of the stroke, 5lbs. per inch for the exhanst steam pressure; in the second third, 81lbs. mean pressure of the steam in the cylinder expanding from 125lbs. into double the volume; and in the last third of the stroke, 16lbs. mean pressnre of the exhausting steam, and 33lbs. mean pressure of the compression. The size of the steam port being $14\frac{1}{2}$in. by $1\frac{1}{4}$in., and the inside of the valve $14\frac{1}{2}$in. by 6in., or 18 square inches and 87 square inches area respectively, the total pressure under the valve amounts to 435lbs. in the first third of the stroke, 1,901lbs. in the second third, and 2,133lbs. in the last third, or a mean pressure of 1,490lbs. throughout; and deducting this from the 22,000lbs. pressure on the back of the valve, there remains an effective pressure of 20,510lbs., or 9 tons upon the back of each valve, and 18 tons npon the pair of valves. In the valves of the passenger engines on the South Western Railway the outside lap is $1\frac{1}{2}$in. instead of 1in. as in the above calculation, which increases the pressure upon each valve to 10 tons.

For the pnrpose of measuring the actual power required to move the valves under these circumstances, experiments have been tried by the writer by removing the valve link-motions of an engine, and connecting the valve-spindle to a lever having the proportion of 20 to 1; from the extremity of the lever a cord was led over pulleys to the front of the engine, and weights were there hung on the cord until the valve began to move, a steam pressure of 125lbs. per inch being maintained in the valve-chest. In the first experiment, which was several times repeated, the weight required to move the valve was 308lbs., amounting to a force of 6,160lbs. exerted on the valve spindle. But as the motion of the valve when once started became rapidly accelerated, a smaller weight was applied to the cord, and the valve was started by hand; and the weight then reqnired to maintain motion steadily in the valve was found from several experiments to be 231lbs., amounting to a force of 4,620lbs. at the valve spindle. Then taking the length of stroke of the valve to be 4in. and the stroke of the piston 22in., the power required to be exerted at the piston to maintain the motion of the valve will be $\frac{4}{22} \times$ 4,620lbs., or 840lbs. To this has to be added the power required to overcome the friction of the eccentric straps; and as this acts on a diameter of 14in., the proportionate force at the piston will be $\frac{14}{22} \times$ 4,620lbs., or 2,940lbs; and taking the coefficient of friction at one-twelfth, the power reqnired at the piston will be $\frac{1}{12} \times$ 2,940lbs., or 245lbs. The total of the two resistances amounts to a force of 1,085lbs at the piston, and the piston being 17in. diameter, this is a constant deduction of 5lbs. per sqnare inch from the effective steam pressure upon the piston, or a loss of about 8 per cent. of the effective power of the engine.

For the purpose of reducing this serious loss the balanced slide-valve forming the subject of the present article has been designed by Mr. Beattie. In Figs. 1 and 2, Plate 378, it is shown as applied to outside cylinder passenger engines, and in Fig. 6 as applied to inside cylinder goods engines.

The body of the valve F is similar in shape to the old D valve, being made cylindrical at the back, Figs. 2 and 6; and it works inside a jacket G of corresponding form, fixed in the steam-chest by the studs H H, Fig. 2. The steam pressure is excluded from the back of the valve by two steam-tight packing rings J J, Figs. 1 and 3, one at each end of the valve, which are fitted into grooves in the body of the valve, and pressed outwards against the jacket by the spiral springs L L placed radially. At the lower side of the valve, the back is turned to the same radius as the jacket for a short portion K of the arc, Figs. 2 and 6, and is there in contact with the jacket; the remaining portion of the back is shaped to a smaller radius, so as to be 1-16th inch clear of the jacket. The packing rings J are pressed by the studs I into the upper angle formed by the jacket and cylinder face, opposite to the lower angle filled by the body of the valve at K. Steam is admitted behind the rings by suitable openings, and the rings are grooved, as shown in section at J J in Fig. 1, to rednce their snrface in contact with the jacket. In Figs. 4 and 5, Plate 378, are shown two other arrangements of the packing rings that have been tried.

The position of the packing rings at each end of the valve is determined by the width of the steam port, as it is necessary to expose to steam pressure at each end of the valve an extent of the back of the valve equal to the area of the port, in order that the valve may not be

lifted from the cylinder face by the pressure of steam in the cylinder after the cut-off has taken place. As the space intervening between the two packing rings in Fig. 1 is the portion that is free from pressure, the necessary area for the steam pressure on the back of the valve is obtained by setting back the inner edge of each packing ring to the required distance from the end of the valve. The spindle of the valve is a straight bar passing freely through it and held in position by the cotter N. The back of the valve may be open, as shown in Figs. 1 and 3; or it may be closed in, and the exhaust passage bridged over, so that the steam may pass through the valve from one end of the steam-chest to the other. The valves are made by preference of hard cast-iron, and the packing rings are also of cast-iron.

For the purpose of measuring the actual power required to move these balanced valves an experiment was carried out similar to that before described for the ordinary valves. The resnlt obtained was that a weight of 98lbs., equal to a force of 1,960lbs. acting at the valve spindle, was required to maintain motiou. It appears, therefore, that whilst a force of 4,620lbs. was required to move the ordinary brass valve, the balanced cast-iron valve was moved with a force of 1,400lbs., or only 30 per cent. of the power required to move the ordinary valve. The amount of pressure on the back of the balanced cast-iron valve is eqnal to the pressure of steam at 125lbs. per square inch, acting on the area of $1\frac{1}{4} \times 17$ inches at each end; and the area of the ungrooved packing rings (Figs. 4 and 2) in contact with the jacket is 1×22 inches for each ring; the total area of rnbbing surface under the pressnre of 125lbs. per inch is therefore 86 square inches, giving a total pressnre of 10,750lbs. Taking then the coefficient of friction to be one-tenth, the power required to move the valve should be 1,075lbs., and by actual trial it amonnted to 1,400lbs.

In reference to the resnlts practically obtained by the employment of these balanced valves, the first point to be noticed is the mechanical advantages attending their use; and not the least important is the facility of moving the reversing lever with steam on, and the avoidance of the excessive wear and tear to which the ordinary valves and the link-motion working them are subjected. It has been found also in practice that there is a considerable saving both in first cost and maintenance with the balanced valves. As the strain npon the valves is so mnch rednced, they may safely and advantageonsly be made of light construction, and of cast-iron in place of brass; and thus the first cost is much diminished. The cost of a pair of ordinary brass valves and spindles complete for main-line coupled passenger engines averages £13 13s.; while the cost of a pair of balanced valves complete for the same class of engine is only £5 7s. There is thns a saving of £8 6s. per engine in first cost. The cost of a pair of ordinary brass valves and spindles complete for passenger tank engines amonnts to £10 2s., while the cost of the balanced slide-valves and spindles for the same class of engine is only £4 18s., showing a saving of £5 4s. in first cost. The cost of a pair of ordinary valves and spindles complete for six-wheel-coupled goods engines is £11 11s., while the cost of the balanced valves is £6 19s., showing a saving of £4 12s. per engine in first cost.

With regard to maintenance it has been found that the wear of the balanced valves is very slight, and it appears probable that they will last six or seven years before requiring to be renewed. Taking, therefore, the life of the ordinary brass valve at eighteen months, it is evident that a great reduction in expense of maintenance is gained with the balanced valves. The packing rings required to be renewed abont once a year, and the grooves cleaned out, the jackets re-bored, and the valves and cylinders faced; the expense of this repair is abont £2 per engine. The valve motion requires slight repair, such as new pins, about once in two years; and contrasting this with the heavy repairs required by the ordinary valves and valve motion, it is seen that there is a great economy in favour of the balanced valves.

Another source of economy is the saving in power required to work the balanced valves, and the consequent saving in fuel, which is an important consideration on railways, where fuel is so expensive. By reference to the recorded consumption of fuel per mile on the London and South Western Railway by twelve engines after being fitted with the balanced valves, as compared with their rate of fuel consumption previously, when working with the ordinary valves, and taking a period of twelve months in each case for comparison, it has been found that the passenger engines have consnmed $2\frac{1}{2}$lbs. less coal per mile since they were altered. It is expected that after some extended experience an average saving of at least $2\frac{1}{2}$lbs. per mile with both passenger and goods engines will be the result; and this amount becomes important when taken as extending over the whole mileage of the year.

Finally, it may be stated that no greater difficulty is found in keeping the balanced valves steam-tight than is experienced with the ordinary pistons; and that no instauces of valves or valve spindles breaking have occurred up to the present time. As many as 180 engines have been fitted with the balanced valves, which are now applied to all engines either newly built or in shop for repair, the result of the past two and a-half years' working having proved so satisfactory.

THE MANUFACTURE OF CANE SUGAR IN THE COLONIES.

(*Continued from page 172.*)

Although at the commencement of this treatise we disclaimed any intention of interfering with the agricultural portion of the subject, innovations of the greatest importance, viz., steam cultivation and steam carriage, have of late years been so extensively adopted, that a short description of the various methods may not be ont of place. The original style of cultivation—and one which is still extensively in use—was to prepare the gronnd for the reception of the cane plants by means of hoes. Where labour is very abundant, and consequently very moderate in price, this system is yet carried on profitably, but we believe even in these exceptional cases it must eventnally be superseded by steam cultivation. The most usual plan at the present time is to prepare the land by means of ploughs, as the price of labour does not admit of hand hoeing, the ploughs being drawn by cattle. Anyone, however, who has watched this method must have been strnck with the laborious slowness of the process, two " spell " of cattle being generally required to draw a single plough at the rate of about one and a-half miles per hour. It is true that in some favoured spots, where an active young elephant may be obtained for a moderate price—say forty pounds—the land can be prepared both quickly and cheaply; but these cases are so exceptional as to require no further notice. The great success of steam ploughs—notably those manufactured by Messrs. John Fowler and Co., of Leeds—for agricultural purposes in this country, attracted the attention a few years ago of some enterprising planters in South America, who very justly considered that if such a system were successful in England, where there is an abundance of labour, it must be still more advantageous for a sugar estate where labour is scarce and inferior. The first essays, however, were not very successful, and it soon became evident that the implements in use in England and on the Continent were unsuited to the requirements of a cane-piece. To anybody who knows anything about a cane field this will not appear at all surprising, as the difference between the cultivation of corn and canes is obvious. The distance between the rows of canes varies considerably in different countries and with different species of canes, but it may, we believe, be fairly set at six feet, the plants being placed about three or four feet apart. To open up the ground for this description of planting a very powerful plough is required, together with engines and tackle in proportion. These requirements have now for some time been supplied by Messrs. Fowler, with, we believe, very satisfactory results, the entire machinery having been remodelled for that particular description of work. The usual style of working is shown in Fig. 1, where it will be seen that two engines supplied with winding gear beneath the boilers are worked on opposite headlands, each alternately drawing the plough towards itself, the

ngine not in work paying out the rope, and at he same time moving forward into position for the return of the implement. The plough which is illnstrated by Fig. 2 is not requirod to turn round at the end of tho journey, as the one set of shares upou which the driver sits is in operation during the journey in one direction, aud upon arriving at the end he has only to change his seat to be ready for the returu journey for the other set. These ploughs are made very much stronger and larger than those usually employed in this country, in order to suit the requirements of the peculiar cultivation necessary for sngar canes.

Fig. 1.

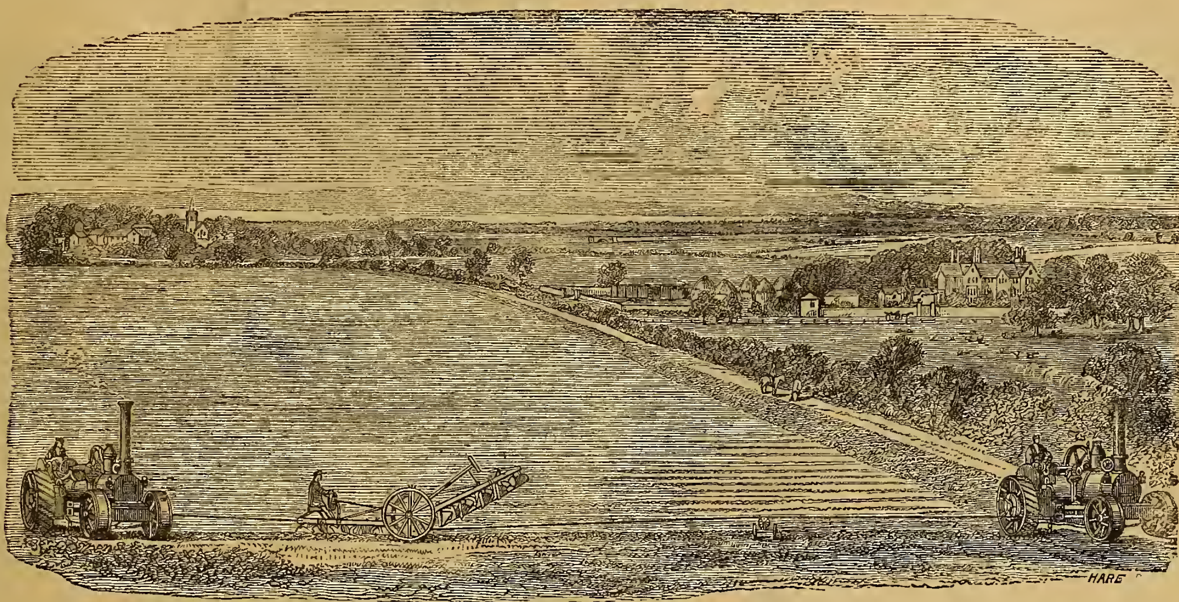
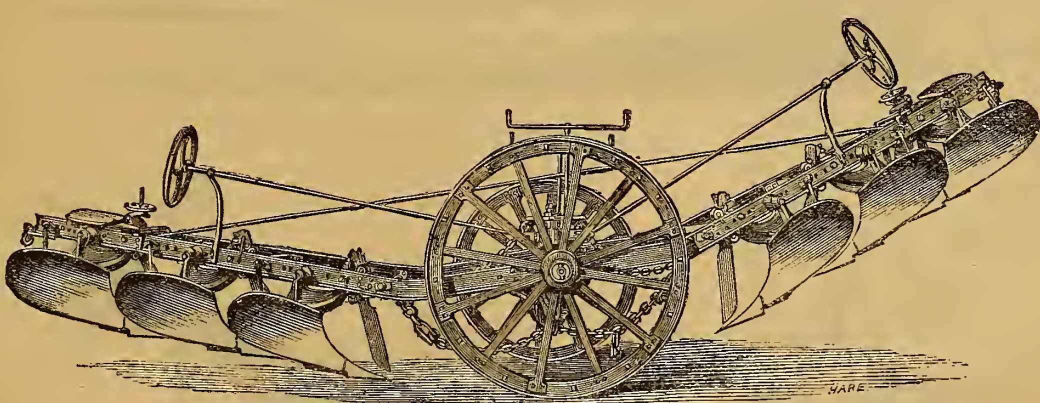


Fig. 2.



Another powerful implement, shown in Fig. 3, is exceedingly useful for opening wide drainage or irrigation ditches, and is very useful for estates situated upon low lands. By means of these ditches, run in rows every twenty or thirty feet, between the canes ; they may either be drained rapidly during wet weather, or irrigated iu the dry season with the greatest facility.

Another very ingenious implemeut may be used, when the soil is not too heavy, for breaking up the land. This is called by the patentees a "turning cultivator," and is illustrated in Fig. 4. This implement is especially adapted for being worked by the double-engine system illustrated in Fig. 1, as it is so arranged that it can be turned round by the engines after travelling to the end of its journey in one direotion so as to be ready at once for the return journey. It consists of a strong iron frame, carrying according to circumstances from five to thirtee tines, and restiug ou three road-wheels, the front wheel being the steeriug wheel. The axle of the two hind wheels is cranked, so that, by its being turned the frame is lowered or raised, and by these means the depth of the tines adjusted. The long end of a draft bar, or "turning lever," is provided with two arms to which the ropes of the two engines are attached. The arms are sot at an angle, for keeping the tail rope clear of the implement. The lever itself is held by a vertical stud fixed to the frame, considerably behind the steering wheel. This position of the draft stud, gives the necessary liberty and power to the steering wheel, and enables it to lead the implement at almost any angle out of the line of the pulling rope. On the short end

of the turning lever is a chain communicating with a quadrant on the crank axle, and as the lever is pulled round the chain acting on the quadrant turns the axle, lifts the frame, and raises the tines out of the ground. The plan of operation is as follows:—As soon as the Cultivator

Fig. 3.

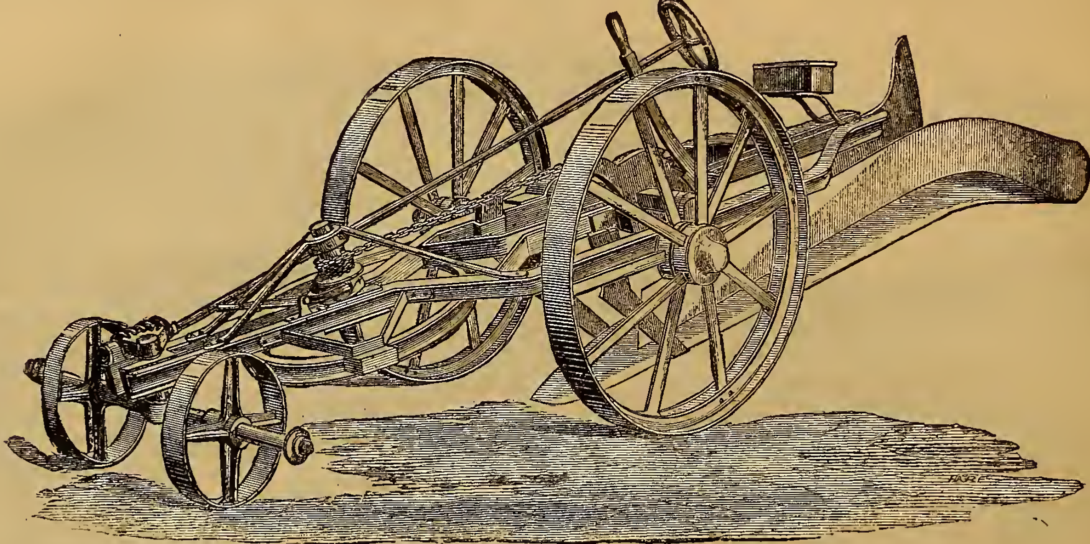


Fig. 4.

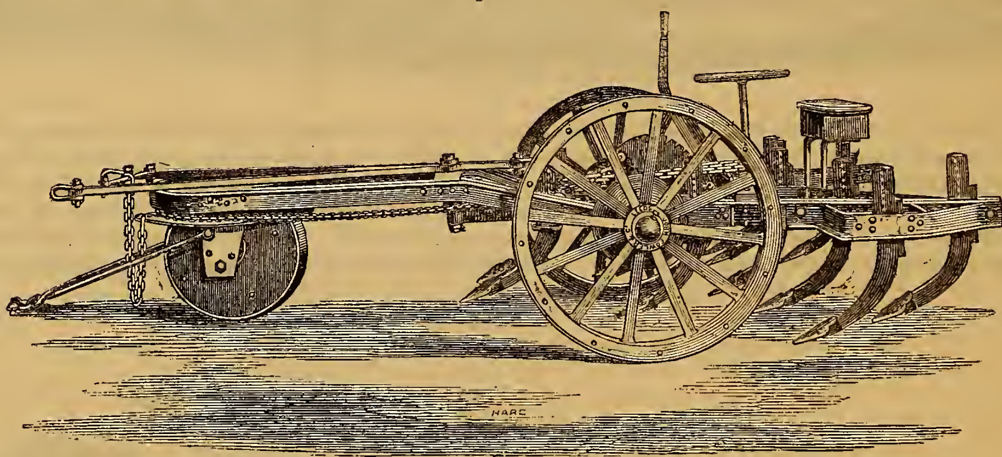
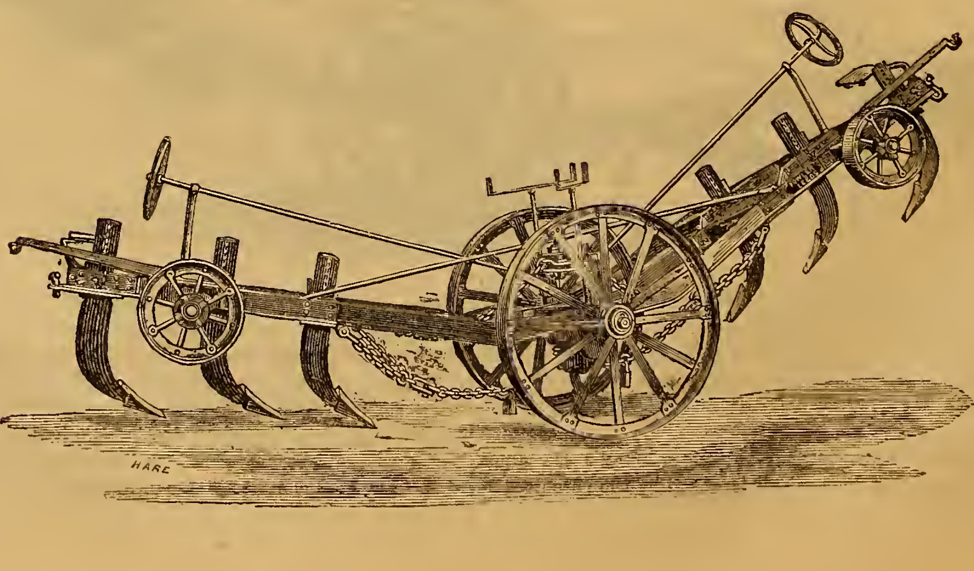


Fig. 5.



is brought up to the headland, the engine on the opposite headland begins to work, and pulling the lever round, lifts the tines out of the ground, which are held up by a catch ; when lifted the reqnired height, the lever strikes against a stop and pulls the implement round into new ground; the man (who never leaves his seat) releases the catch, the tincs drop into the ground, and the implement is drawn across the field.

The principal advantages of this excellent implement are as follows:— Its size is only limited by the power of the engines, which thns may be used to their utmost capability. It smashes up the soil, working steadily, and always preserving a perfectly uniform depth. Even the largest implements of this description require only one man in attendance. In turning round, no additional work whatever is required, and scarcely any time is lost, whilst the implement, however wide, at once moves into new land, leaving small and clean headlands. On average soil 30 to 50 acres per day may be efficiently cultivated. Ridging bodies attached to the frame of this cultivator will produce a most effective and easily-handled ridging implement.

For working up new land when stones, roots, and other natural impediments occur a very powerfnl grubber may be used with advantage; the implement being driven with the same machinery as that described above. This grubber which is illustrated in Fig. 5 is a remarkably nseful implement for thoroughly and speedily clearing land. Its power is enormous, defying almost any obstacles that may present themselves and at the same time the depth (2ft. 6in. to 3ft.) at which it works thoroughly aerate the ground. Besides the cultivation of the soil the removal of the crop has also been successfully performed by steam power. In Fig, 6 is shown a plan of Mr. Greig's system of clearing off the ripe canes after being cut. Up to the present time we believe that no machine has been tried for cutting the canes, and considering the substance to be cut and the distance between the "stools" but little advantage over the old system of hand cntting could be expected. In "clearing off," or carrying the canes we consider the system of Mr. Greig would be not only more economical but what is perhaps of greater importance more rapid than the present system of carting in bullock waggons or mule carts. It is now proposed to construct a nnmber of waggons, each able to carry three or four tons of cane, on three or four wheels, of which the front wheels are steerable. One of these waggons (Fig. 7) was exhibited at Wolverhampton. The steering gear is similar in construction to the well-known front wheel of Messrs. Fowler and Co's tnrning cultivator. The waggon rests on a turn-table, which is carried by the front wheel, the draught stud being placed behind this tnrntable, so as to give to the steering wheel a leverage over the pull which it otherwise would not possess. Fonr or more of these waggons are attached to each other and brought to the field by small traction engines. These never leave the roads which divide the sngar fields, and form, as a rule, the headlands for the ploughing engines during the time of ploughing. At the two opposite ends of the field which is being cut, two ordinary ploughing engines are placed, their ropes being connected by a shackle, to which a spare chain is fixed. The waggons are attached to this chain and hanled over the field from one engine to the other, being steered along the uncut edge of the sugar cane and loaded at the same time. Thus the train arrives full at the other end and is taken away bv the traction engine, which in the meantime has run round the field.

Where large central sugar mills are used for several estates agricultural railways are generally employed to connect the estate with the factory. In this ease the sugar waggons worked by the traction engine are provided with a movable cradle into which the cane is placed on the railway truck, so that no further handling of the cane is required.

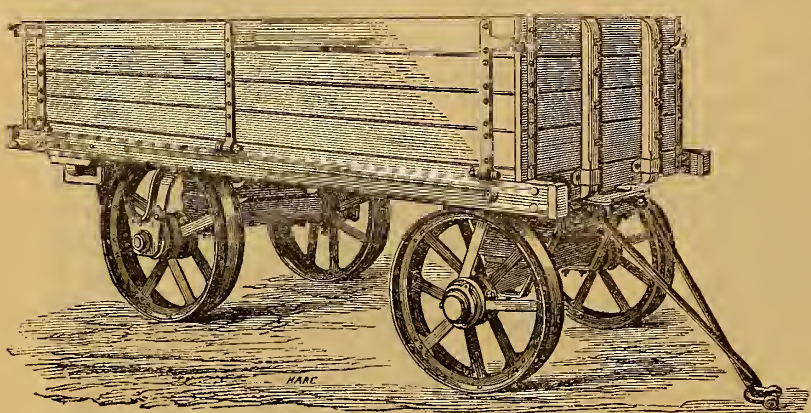
In many plaees where sugar is, or might be, cultivated tbe land is very level and but a fcw feet above the water, and in some cases frequently below the surface of the water. Thns in North and South America, Egypt, Siam, and India there are vast tracts of land thus sitnated, and which, if cultivated, would be more than sufficient for the supply of sugar

Fig. 6.

to the whole world. In these cases steam cultivation is eminently advantageous as the proximity of water offers many advantages in its adoption. Thus, the soil which generally consists of alluvial deposit is usually heavy and deep; remarkably good for the canes but not easily ploughed by the use of cattle. The best method to adopt in cultivating an estate of this description is, to cut parallel canals at convenient distances apart of, say, 500 yards and of sufficient width to navigate a barge; the width being doubled here and there to allow two barges to pass one another. The soil thrown out of the canal will form a bank on each side which will serve to keep out the water from the fields when necessary. These canals, which would, of course, have one end running into the river can be joined at their other ends by a cross canal, and also at any portion of their length if deemed necessary. When once this is done the entire system of cultivating and carrying canes is both simple and economical.

Thus, for preparing the soil a couple of barges one in each of two adjoining parallel canals carry a steam plough which may be either portable or fitted to the vessel. By this means the whole land contained between these canals may be cultivated, no headlands being required. After the land thus prepared has been planted, should the cane require irrigation and the water be too low to flow over the land, as must generally be the case, a centrifugal pump driven by the same engine that worked the plough may be employed for the purpose. This pump may

Fig. 7.



also be either temporarily or permanently fitted in the barge. As the canes grow and require banking up the same engines might be used for driving a plough suitable for the purpose. Again, should the canes require cleaning (weeding, not trashing) the process could be easily performed by the same engines working a hoe or other suitable machine instead of the plough. When the canes arrived at maturity and were cut, the same engine in the same barge might be employed to tow lighters and carry the canes to the sugar house by having a small screw fitted so that it might be driven from the engine, or possibly the centrifugal pump already fixed in the barge might be utilised for the purpose of hydraulic propulsion.

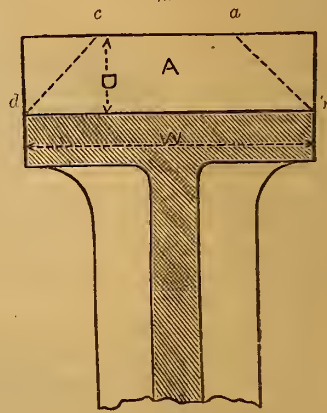
It is evident therefore that a couple of engines fitted in suitable barges might perform all the heavy work required outside the sugar house. Other duties might be mentioned which the engines would be capable of performing during their leisure, if they had any. Such, for instances as sawing wood, grinding rice, &c., and possibly of shipping the sugar after it was made. Although engines of this description must be good, and are, consequently, expensive, the number of duties they might be made to perform, many of which could not be properly done by hand labour, make them almost indispensable. Moreover, the amount saved in manual labour would speedily pay for the first cost of the engines.

STRENGTH OF SPUR WHEELS.

By FRANCIS CAMPIN, C.E.

In the present paper we purpose making some remarks upon the strength of mill-gearing, in order to set forth the principles upon which machinery of this description should be designed.

Fig. 1.



Let A., Fig. 1, represent a section of the rim of a spur-wheel taken over one of the areas, it is required to calculate the strength of the teeth of the wheel.

According to the old fashion it has been customary to calculate the strength on the line a—b, or c—d, as the whole strength of the wheel; but if this were correct, the lines being at an angle of 45 degrees to the face of the wheel, it is evident that it would be useless to make the width more than twice the depth of the tooth.

It is well known, however, that wheels very commonly lose the corners from their teeth and yet continue to work well for years afterwards. In point of fact, the tooth of the wheel is a cantilever, and its theoretical form should be to taper in width from its base b d to its point. Although we have heard it asserted that the strain upon the tooth of a wheel is neither more nor less than a shearing strain—a statement which is fallacious on the face of it, as the strain must be of a bending nature, and the maximum strain being reached when the power is being transmitted through the extreme end or point of the tooth.

It is found that a cantilever of cast-iron, one inch long, one inch wide. and one inch thick, breaks under an extreme load of 8,000lbs.

To find the breaking weight of any given cast-iron cantilever loaded at the end:—

Multiply the breadth in inches by the square of the thickness in inches,, the product by 8,000, and divide by the length in inches.

Let w = breadth in inches,
D = length ,,
t = thickness ,,
W = breaking weight.

$$W = \frac{8{,}000 \times w \times t^2}{D}$$

Example—Let t = 2 inches, D = 3 inches, w = 6 inches.

$$W = \frac{8{,}000 \times 6 \times 2^2}{3} = 64{,}000\text{lbs.}$$

breaking weight.

In practice it is usual to make the working strain one-sixth of the breaking weight; let L = safe load

$$L = \frac{8{,}000 \times w \times t^2}{6 \times D}$$

$$= \frac{1{,}333 \times w \times t^2}{D}$$

Therefore

$$t^2 = \frac{D\,L}{1{,}333 \times w}$$

$$t = \sqrt{\frac{D\,L}{1{,}333 \times w}}$$

Which is the proper rule for calculating the thickness of the teeth of spur wheels.

Let the force transmitted by a spur wheel be 10,000lbs., the length of the teeth being 3in., and the breadth 6in., then—

$$t = \sqrt{\frac{D\ L}{1{,}333 \times w}} = \sqrt{\frac{6 \times 10{,}000}{1{,}333 \times 3}} = \sqrt{15} = 3.87\text{in.}$$

It is, however, in many cases more convenient to calculate at once the pitch of the wheels instead of the thickness of teeth.

According to the Manchester scale the thickness of a tooth is equal to 0·45 pitch. Therefore, if P = pitch

$$P = t \times 2.22$$

Therefore—

$$P = 2.22t = 2.22\sqrt{\frac{D\ L}{1333.w}}$$

$$= \sqrt{\frac{5\ D\ L}{1333.w}} = \sqrt{\frac{D\ L}{266.w}}$$

Let the force transmitted by the wheel be 4,000lbs., the length of tooth 2in., and the breadth on face, 4in., then the pitch will be thus found—

$$P = \sqrt{\frac{D\ L}{266.w}} = \sqrt{\frac{2 \times 4000}{266 \times 4}} = \sqrt{7.5} = 2.73\text{in. pitch.}$$

If we could be always certain of having the wheels very accurately made it would not be necessary to make one tooth carry the whole strain; but as this exact workmanship cannot always be secured, we have for the sake of safety to consider the whole strain as possibly coming on the point of one tooth, and make the wheels strong in proportion.

We must now make a few remarks as to the shrouding of wheels. In this case we have undoubtedly, in addition to the strength of the tooth regarded as a cantilever, the resistance to shearing at each end where the tooth joins the shroud. Let us assume the teeth to be shrouded on both sides up to the pitch line, that is half way up.

Taking the first example where t = 2in., D = 3in., and w = 6in., we found—

$$W = \frac{8{,}000 \times 6 \times 2^2}{3} = 64{,}000\text{lbs.}$$

breaking weight merely regarding the tooth as a cantilever. Now, we have shearing area to the extent of half the length of the tooth multiplied by its thickness and by 2, there being a shroud on each side of the wheel; hence the shearing area will be—

$$1.5 \times 2 \times 2 = 6 \text{ square inches.}$$

Taking the shearing resistance of cast iron at 17,000lbs. per sectional square inch the additional resistance afforded by the shrouding will be—

$$17{,}000 \times 6 = 102{,}000\text{lbs.}$$

or nearly twice the strength of the tooth itself.

In any case it may safely be assumed that shrouding the teeth double their strength, and in most cases it does more than this.

Having determined the strength of the teeth, it becomes necessary to find a law for the strength of the arms of wheels, through which the strain is transmitted from the rim to the shaft, or *vice versâ.*

It will be observed that the strain will not be constant on all the arms, as those nearest to the teeth in action will be the most strained, and the strain will diminish on the following arms, so that the strain on any one arm will always be varying.

(To be continued.)

Steam Fire Engines.—The Prussian dockyards are adopting the "Admiralty" pattern steam fire-engine of Messrs. Merryweather and Sons. These are the most powerful steam fire-engines introduced: they are capable of discharging 1,200 gallons per minute to a height of 230ft., through a nozzle 1⅝in. in diameter. The English Government are provided with five such engines. Messrs. Merryweather are now building the fourth engine for Prussia.

THE ROYAL AGRICULTURAL SOCIETY'S SHOW AT CARDIFF.

The following is a list of prizes to be competed for at the next show of the Royal Agricultural Society at Cardiff, together with the conditions required to be fulfilled for that purpose:—

Prizes.

Class 1, for the best portable steam-engine (not self-moving), not exceeding 8-horse power, £40; for the second best ditto, £20.

Class 2, for the best combined portable thrashing and finishing machine, to be worked by steam, and adapted to the preparation and sorting of corn for market, £40.; for the second best ditto, £20.

Class 3, for the best combined portable thrashing machine, to be worked by steam, which has no corn screen or other apparatus for the grain for market, £40; for the second best ditto, £20.

Class 4, for the best straw elevator, to be worked by steam in connection with a thrashing machine, £10; for the second best ditto, £5.

Class 5, for the best straw or hay elevator, to be worked by horse-power, £10; for the second best ditto, £5.

Class 6, for the best seed drawer, £10.

Class 7, for the best corn dressing machine, £15; for the second ditto, £10; for the third best ditto, £5.

Class 8, for the best corn screen, £10; for the second best ditto, £5.

Miscellaneous awards to agricultural articles not included in the quinquennial rotation—ten silver medals.

In the class for which one prize only is offered the judges will be empowered to divide it equally between two competing implements, if they consider them equal in merit.

Conditions.

Steam Engines.—All engines must be fitted with a steam-indicator, in addition to the ordinary spring balance, which indicator must be proved by the indicator of the Society.

Portable Engines.—1. All the general conditions respecting steam engines and boilers will have to be observed.

2. The nominal power of the engines entered for trial will be taken at one-third the indicated power, at 60lb. pressure in the boiler, cutting off at three-fourths the stroke, and the periphery of the fly-wheel running 1,884ft. per minute.

3. The engines will be tested by the Society's friction brakes, worked by means of connecting rod and universal joints direct from the crank shaft. Each engine will have to be fitted with a clutch, shown in detail in Fig. 4 Form A of engineer's instructions; and to facilitate the Society's arrangements the height of the crank shaft of each engine above the ground must be stated when the specification is sent in to the secretary.

4. The engines will be tested for economy in coal, water, lubrication, and steadiness in running. Indicator diagrams will also be taken, and, therefore, the preparations for receiving the indicators, described in Form A, must be provided.

5. During the trial runs one man only will be allowed to attend the engine. Over or under-running will not be permitted, steady running as nearly as possible at the speed declared at entry will be considered a point of merit. The engines must be fitted with governors, and the efficiency of the latter will be tested after the trial for economy of working are over, by suddenly varying the load on the brake.

6. Exhibitors shall, on making their final specifications, elect at what steam pressure, not exceeding the declared pressure, what horse-power on the brake, and what number of revolutions they would wish to be tried.

7. The order in which the several engines will be tested will be determined by the stewards, who will decide by lot.

8. Detached feed-water heaters not ordinarily sold with engines, and included in the prices entered, will not be allowed, but heaters permanently fixed to the engines or arrangements for carrying waste steam to the water tanks, provided they are included in the price of the engine, will be admitted.

9. The trials of the steam engines will be made with the Llangennech coal.

Thrashing machines.—10. The thrashing machines will be driven by a portable engine through a registering dynamometer, both provided by the Society. The driving pulleys on the machines must be adopted to 1,884ft. per minute speed of driving belt.

11. The merits of the machines will depend upon the prices, economy of power, and time; the marks obtained for clean thrashing, clean shaking, freedom from cavings, freedom of chaff from corn, from cavings and from seeds, unbroken straw, uninjured corn, cleanness of delivery from machine, and perfection of finishing in Class 2. The points representing perfection will be as follow:—Clean thrashing 150, clean shaking 40, freedom from cavings 30, chaff free from corn 50, chaff free from cavings 20, chaff free from seeds 40, straw unbroken 20, corn uninjured 70, cleanness of delivery from machine, *i.e.*, absence of lodgment in

screens, &c., 10, perfection of finishing, that is screening or sorting in Class 3 only, 20; total, 450.

12. The sheaves to be thrashed will be kept under cover, the stacks will be worked down vertically, so as to give each machine as nearly as possible the same quality of work; the sheaves will be served out by weight to each machine. The straw resulting will be re-thrashed, and the various products delivered by the machines, as well as the corn separated by the second thrashing, will be carefully weighed, and samples set apart for final comparison.

13. Means must be provided for examining the inside of the machines as perfectly as possible, in order to ascertain how completely the various products are delivered; it will be a point of merit in a machine to empty itself completely, and leave no lodgments in the screens, &c.

14. Those machines which appear to the judges of sufficient merit will be run for a prolonged trial, in order to enable a more correct and satisfactory judgment of their merits to be arrived at.

15. The machines in classes 4, 5, 6, 7, and 8 will be judged chiefly with reference to the manner in which they perform their work, to the goodness of design and workmanship, and to their cost. Dynamometers will be used whenever the judges think it advisable to determine the amount of power necessary to drive the machines.

General Regulations respecting Steam Engines and Boilers.—30. There will be no restriction as to the construction of steam engines or boilers, except that the pressure of steam shall not exceed 80lb., and the engineers of the Society must be satisfied that the bursting strength of the engine or boiler is at least four times its working pressure, and that a hydraulic test of one and a-half times the working pressure has been satisfactorily applied.

31. Each exhibitor on sending in his specification must declare the greatest pressure at which he proposes to work his boiler or engine.

32. No old boilers, that is, boilers that have manifestly been at work for a considerable time, will be admitted without special thorough examination and a certificate of safety from the Society's engineers.

33. Each boiler, of whatever form or size, must be provided with the following mountings:—Two safety-valves, each of sufficient size to let off all the steam the boiler can generate without allowing the pressure to rise ten per cent. above the pressure to which the valve is set. Two sets of gauges for ascertaining the water level. One steam pressure gauge, which must be tested and verified by the Society's engineers before the boiler can be used. A half-inch cock, terminating in a half-inch male gas thread for the purpose of receiving the Society's testing pump. One check feed valve, immediately attached to the boiler, in addition to the ordinary pump valves, whenever the feed is introduced below the lowest safe water level, or where there is a length of feed pipe between the engine and boiler.

34. No boiler or engine will be allowed to work without having the engineer's certificate of safety, and the limit of pressure conspicuously attached to it.

35. Any engine which is entered for competition, or for working in the yard of "Machinery in Motion," which from defect in construction or any other cause, is, in the opinion of the judges and consulting engineer, "unsafe," shall not be allowed to work on the Society's premises; and, further, the word "unsafe" shall be attached to the engine during the remainder of the exhibition.

36. In competitive trials before the judges, Llangennech coal, provided by the Society, will be used. In the show-yard exhibitors must find their own coal; it must be consumed without the production of smoke, and efficient spark-catchers must be fitted to the chimneys.

37. Water for the supply of the steam boilers will be provided by the Society.

38. Exhibitors must be provided with all the appliances necessary for taking the working parts of the machinery to pieces for examination, should the judges or engineers require it.

AMERICAN VIEWS ON PATENT LAWS.

The Hon. Charles Mason, late Commissioner of Patents, has written George Haseltine, M.A., chairman of the meeting on the patent laws, an instructive letter, of which we give a brief abstract:—"I have," he says, "never had any serious doubt of the wisdom of judicious system of patent laws. The public welfare is best promoted by inspiring individual effort in respect to invention, through the motive of private gain; and who can more justly claim the exclusive use of any property than he who has brought it into being?—The American system of examination is productive of much advantage to inventors and the public, but I doubt the wisdom of lodging in officials an unlimited power of rejection. If the action of examiners were advisory and adjuvant, reserving to an applicant the ultimate right to a patent, at his own risk, the chief objection to this system would be removed.—The fees by all means should be small—barely sufficient to defray the expenses of the patent office. Inventors are benefactors, and as a class are poorly compensated for their labour. The imposition of large fees discourages invention, and thereby checks the progress of civilization. This cannot be sound policy.—Experience leads me to the conclusion, that patents should be granted for more than fourteen years, but this term, in most cases of merit, is extended by our office to twenty-one, and often by Congress to twenty-eight years. The new law limits the term of a patent to seventeen years, which will, no doubt, hereafter be extended; and I do not think twenty-one years too long a period for the original grant.—In one respect I like your system better than ours—your fees are paid in instalments, giving the patentee the option of keeping his patent alive. The French plan of annuities is carrying the matter rather too far. I think the English system better than the French or the American, and all that is needed is a reduced rate of fees.—Experts are often very useful, but they are regarded with suspicion, and their opinions have little weight in our courts, therefore, what might be a great evil, carries in some measure its own remedy, and the interposition of jurors in patent suits is generally avoided by obtaining injunctions in chancery, which is our usual remedy for infringements."

EUPHRATES VALLEY COMPANY.

The House of Commons' Select Committee appointed to report upon the subject of railway communication between the Mediterranean, the Black Sea, and the Persian Gulf was not nominated until July, and all that the committee was able to do was to take some evidence, which has now been published, and to recommended its own re-appointment next Session to continue the inquiry. Sir H. Rawlinson gave the committee a general account of the various routes which have been under consideration. General F. R. Chesney was examined, and described and recommended the Euphrates line going from the Mediterranean to the Persian Gulf. He was followed by Mr. W. Ainsworth, who was attached to General Chesney's mission in 1835-37; by Captain E. P. Charlewood, also attached to that expedition; and by Mr. Telford Macneill, who has been engaged in surveys with a view to this Euphrates line. Mr. K. T. Lynch, who is acquainted with the country, and who furnished Mr. Andrew with information, also gave evidence before the committee. Sir G. Jenkinson, on whose motion the committee was appointed, gave an account of the part he has taken in the matter. Sir J. Mac-Neill, who was also examined, stated that engineers would now be able to carry a line over the Balan Pass to Aleppo, to be worked with locomotive engines. The only other witness examined was Mr. W. J. Maxwell, civil engineer, recently returned from Asia Minor, whither he went to examine the Balan Pass and the continuance of a line to Aleppo, and he states that the pass is practicable. The elevation crossed would be 2,173ft.; snow is rarely upon the ground, the oldest inhabitant of Balan remembers 3ft. of snow on one occasion, but this is spoken of in the neighbourhood as a most extraordinary occurence. In a paper handed in by him Mr. Maxwell states that the difficulties to be encountered in carrying a railway over the Balan (or Beilan) pass are not for a moment to be compared with those of the Mont Cenis Railway, and that it is not at all probable that the native tribes would interfere with a railway by the proposed route, but that some small subsidies might have to be given.

TELEGRAPHY IN TURKEY.

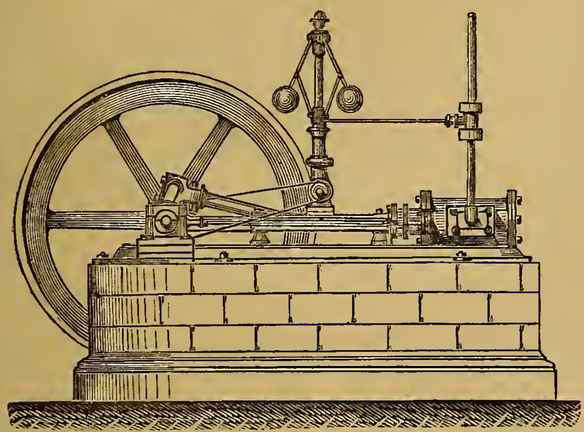
The Constantinople journals announce that Mr. Joyce Perceval, who superintended the erection of the telegraph between Bagdad and Bussora, and Bagdad and the Persian frontier, has arrived in Constantinople for the purpose of proposing to the Turkish Government a line to connect that city with Arabia by a submarine cable from Akaba to Jiddah, from Jiddah to Gunfoodah and Mocca and Hodidah, which are the principal ports under the jurisdiction of Turkey on the shores of the Red Sea. Mr. Perceval proposes to run a land line from Jerusalem or Beyrout, overland, leaving Egypt seventy miles to the right, commencing in deep water at the Gulf of Akaba, and getting into the Red Sea to the right of the Rock of Tyran, which is thirty miles to the left of the dangerous islands of Jubal, situated about ninety-six miles from Suez. He also proposes that all the land stations shall be forfeited stations, and that, in case of emergency, there could be a floating station a mile or two off the last mentioned towns. It is stated that by carrying out these suggestions, notwithstanding any disturbance that might transpire amongst the rebellious Arabs ashore, Turkey will be in hourly communication with her colonies. Of course there are difficulties, especially between Jerusalem and Akaba, but in 1862-3-4 and 5 difficulties occurred, which Mr. Perceval had to overcome before he finished the lines now in operation, and he now relies confidently upon his fifteen years' residence amongst the Arabs to retain the popularity and influence formerly exercised for the peaceful working of the line. It is computed that the project can be completed within twelve months, that the cost will not exceed £195,000, and that three-fourths of the expenses will be realised from the commercial traffic which will at once arise between Constantinople and the Red Sea.

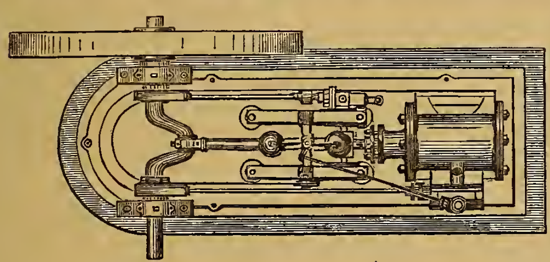
HORIZONTAL ENGINE.

By Messrs. C. Russell and Co.

When at the Royal Agricultural Society's Show, at Wolverhampton, we noticed a well-made horizontal engine, and although it possessed no particular novelty, the extraordinarily moderate price at which it was offered considerably astonished us. The difficnlty of obtaining a really well made small engine at anything like a moderate price is well known. Most of the engines of this class appear to have been "thrown together" in the roughest possible manner, and consequently they not unfreqnently cost as much to make them work properly as they did to pnrchase.

In the acoompanying engravings an elevation and plan is given of a





2½ h.p. engine by Messrs. Russell and Co., of Gracechuroh-street; the diameter of the cylinder being 5½in., and length of stroke, 9in. It will be seen that the engine is self contained, having a crank bearing on each side of the bed plate. The governor is made large, so as to give it sufficient control over the engine. This is a point of considerable importance with small engines, as the usual practice is to make the arms of the governor in small engines so short that it becomes practically nseless for regulating the speed of the engine. The piston is fitted with two metallic packing rings; the fly-wheel is turned, and all the working parts are turned out bright. On the whole these engines appear to be first-class jobs, and it is difficult to understand how they can be turned out for the money.

OPENING OF THE MONT CENIS TUNNEL.

This grand and most important undertaking has at length been accomplished. We say at length because it has taken nearly half a generation to complete but considering the stupendous work to be achieved the time mnst be considered short. It must be remembered that when it was first began in 1857 the science of civil engineering was not nearly so far advanced as it is at present, tunnelling by machinery had yet to be invented or at least to be practically perfected. Hence, when this important work was projected thirty years was considered a fair amount of time for performing the work and it was thought even five years afterwards, viz., in 1862, when a fresh agreement was arranged between the Italians and the French that twenty years from that time was a moderate calcnlation for the date of its completion. The energy with which it was carried on, however, combined with new rock boring, or tunnelling-machines which happily made their appearance at the right time, have completed the tunnel in less than ten years. In the race between the French and Italian nations to complete their respective portions of the work it must be acknowledged that the latter have won; although this may to a certain cxtent be owing to the disastrous war the French have lately had to sustain.

The progress of the tunnel together with the various machines used for expediting its completion have been so frequently described in the pages of The Artizan that further comment upon that subject is superfluons. We need only remark that the alarmists who prophecied that the accnmulation of impure air in the tunnel would render it useles have been totally mistaken. How any person with the least pretension to scientific knowledge could have imagined that the air of a tunnel in which the workmen could carry on their operations with comfort before communication was established and, consequently, before any throngh amount of air was possible should, after snch current was affected, become worse, is a matter of astonishment.

The "Offical Experimental Excursion" took place on the 15th ult. and an engineer who was fortunate enough to accompany it writes to a contemporary as follows:—

"Our carriage was last in the line, and as the engine worked backwards we were close on it. Both our windows were wide open, and we had not the least imaginable inconvenience from smoke or steam. There was no perceptible difference between the inside and outside air, and one of my companions slumbered through nearly the whole distance. The faot that the engine was in our rear was certainly in our favour, but the unanimous evidence of all who had come through in the morning went far to establish that they also had experienced no unpleasant sensation, and the difference of temperature could only be detected by Valvassori's glass, which marked a few degrees of additional warmth in the tunnel. The highest degree attained in to-day's journey has been 18 deg. centigrade. Grattoni's glass in a previous trip rose to 21 deg. A more trinmphant success than has in every respect crowned this great work could hardly have been anticipated by its most sanguine well-wishers. Our pace throughout the crossing seemed fairly rapid and even; and the time employed, both in the np and down journey of between seven and eight English miles, was precisely 38 minutes, but the average time allowed to the trains when the line shall be in operation, is calculated at 20 minutes.

On the 17th ult. the train for the inauguration of the Mont Cenis Tunnel, consisting of 22 carriages, started from Bardonnèche at 10.30 in the morning, and arrived at Modane at 11, the run through the tunnel having been accomplished in 20 minntes, without the experience of any inconvenience. The French Home Minister (M. Lefranc), accompanied by other French Officials, was waiting the arrival of the train, in order to salute the Italian Ministers and authorities. After a most cordial meeting the festive train returned to Bardonnèche at noon. At 3 o'clock a banquet was given to a thonsand persons. The French Minister M. Lefranc, the Italian Ministers, and several distinguished foreigners were present.

Signor Visconti-Venosta drank "To the Prosperity of France." M. Lefranc, in reply, paid a high tribute to the scientific and political attainments of the Italians, and drank "To the Union of France and Italy" amid tremendous applause. Signor Devincenzi proposed "The Health of all participators in the great work," and M. Lesiep Ceresole, representative of Switzerland, congratulated the assembly on the triumph achieved. Signor Sella saw, in the piercing of the Tunnel, an instance of what Italy would do. M. Lesseps drank to the political union of France and Italy, and Signor Rora to their commercial union.

PRESERVED MEAT FROM AUSTRALIA.

A short time ago we had the pleasure of receiving from the Victoria Meat Preserving Company, of 24, Laurence Pountney Lane, a few specimens of meat preserved by their method in Anstralia and forwarded to this country in hermetically sealed tins. Although from our extensive acquaintance of preserved fresh meats both in the West and East Indies where in many places it is a case of Hobson's choice—that or none,—we did not anticipate the idea with delight, it was determined to give them a fair trial. The result however was agreeably disappointing, the peculiar insipid "tinny" flavour usnal in such meat was conspicuous by its absence, and we believe, that, without being informed beforehand, any one trying it would not have suspected that it was other than the nsual butcher's supply. This favourable resnlt may have been occasioned by the method of dressing viz., with fresh English vegetables and serving up as a stew or haricot, but if such a result can be obtained by such simple means, it should be a great boon to edncated men of limited income. We do not expect it would be patronised to any great extent by working men as they are generally in the highest degree fastidious, and the bare idea of anything at a lower price than that to be had in the ordinary market would be snfficient reason for them to reject it, but to those above such prejudices we cordially recommend it a fair trial.

THE BRITISH ASSOCIATION.

RAILWAY GAUGES.

By R. F. FAIRLIE.

I had the honour last year, of reading before this Association a paper upon "The Gauge for the Railways of the Future," in which I pointed out the capacities of narrow gauge lines, and showed how unfavourably our own railway system, as at present worked, contrasts with such lines when properly handled. The great truths I then put forward were too startling to be received without some degree of ridicule and incredulity; and although I announced them in the full conviction that sooner or later they would be fully acknowledged, I was then little prepared for the rapidity with which that acknowledgment has come. The report of the Imperial Russian Commission upon the Festiniog Railway, produced a similar inquiry on the part of the Indian Government. I had once more the satisfaction of attending a Royal Commission, appointed to investigate the question of narrow gauge; and the results obtained on the second occasion were as satisfactory as those on the first. In Russia, at the instance of His Excellency Count Bobrinskoy, His Imperial Majesty the Emperor commanded a line of narrow gauge railway to be at once commenced, and a number of my engines to be constructed, in order that the accuracy of all I had asserted on the subject, and had shown to the Commission upon the Festiniog Railway, might be proved upon a more extended scale; and that the exact value of a narrow gauge system, for national service, might be ascertained by the fullest tests of experience. The Association will, perhaps, pardon a brief digression, while I here place on record, as a matter of history, the eminent services rendered to the cause of narrow gauge extension by the Russian Commission, and also by Mr. Spooner, the engineer and manager of the Festiniog Railway. This little line, of only 1ft. 11½in. gauge, was originally constructed for horse traffic; but was worked after a time by small locomotive engines, resembling, in everything but dimensions, those in common use in England. As thus worked, the traffic out-grew the carrying capacity of the line; and powers to construct a second track were actually obtained. At this conjuncture, Mr. Spooner had the sagacity to perceive the advantage that would accrue from the employment or my system of traction, of which he had read, and the determination to carry out his perception to a practical issue. I constructed for him the now well-known "Little Wonder" locomotive, and thus gave him, on his single line, two-and-a-half times the carrying capacity that he had possessed before. The second track was thus rendered unnecessary, and it has never been made. In the application of all novelties there must ever be risks of failure from unforeseen causes, and hence many, even when they recognise a truth, shrink from the responsibility of being the first to carry it into practice. The acceptance of this responsibility by Mr. Spooner, the opportunities that he thus afforded me of proving the working value of my principles, and the facilities for inspection and experiment that he has since courteously allowed, all fairly entitle him to be considered the father, as his tiny railway has certainly been the cradle, of the the narrow gauge system of the future. The next step was made by the Russian Commission. It would be difficult for me to do justice to the infinite care and pains with which Count Bobrinskoy, the President of that Commission, investigated every detail before arriving at his conclusion, or to the earnestness with which he afterwards pushed this conclusion to its legitimate results. In Russia, as in other countries, there are men whose interests or whose prejudices lead them to cling to existing systems, and the opposition which proceeded from such persons could only have been overcome by the strength of clear convictions, of unsullied integrity, and of indomitable resolution. Count Bobrinskoy was worthily assisted in his novel and important duty by the other members of the Commission, among whom I may name M. B. Saloff, Professor at the Technical School of Engineering, St. Petersburg; M. von Desen, now resident engineer in charge of the works; and M. Schoubersky, in charge of the rolling stock of the Imperial Livny Railway. To these gentlemen the entire civilised world owes a deep debt of gratitude. The line which was constructed and equipped in accordance with their report has now for several months been in operation. The results of its working establish all that I claimed for the narrow gauge; and the final official trials that will take place this month will determine the general adoption of the 3ft. 6in. gauge in Russia, together with the employment of my locomotives, without which the value of the narrow gauge at once sinks into comparative insignificance. This rapid action is due to the promptness with which His Imperial Majesty of Russia appreciates progress, to his freedom from prejudice, and to the fact that I have never advanced anything which I have not been able to prove. In India, although I believe ground has not yet been broken, a metre gauge has been decreed for general introduction; and the strongest advocates for the retention of the 5ft. 6in. gauge have been entirely defeated. In Australia, Tasmania, will be built as fast as means that have been straitened and opinions that have been prejudiced will permit. In South America to a great extent, and in North America—I speak of the United States—to a marvellous degree, the reform I have so long, and at last so successfully, advocated, is making way with an astonishing rapidity. Some 2,000 miles of narrow gauge line are under construction; the great Denver and Rio Grande Railway, 850 miles in length, is being built upon the gauge I have made specially my own; and I may mention that this width of 3ft. was decided upon by the President and principal officers of the company after considerable investigation of the principles of my system recommended to their consideration by Mr. George Allan, C.E., who at an early period, became strongly convinced of its advantages. A great transcontinental railway from the East to the Pacific is being organised, which, it is expected, will also be on the new narrow gauge. California is building similar lines; the Western States and Territories—pastoral, agricultural, and mineral—are building them; Massachusetts, already covered with a network of ordinary gauge railways, is legislating for them; and many others of the Eastern States are earnestly considering the advisability of their immediate construction. As little as yourselves could I have last year imagined that all this progress would have been made in less than twelve months. At that time I was discouraged on almost all sides; I was hampered by the weight of prejudice and of opposition of every kind; but knowing I was right—knowing that the work I had in hand was one which would benefit the whole of the civilised world—knowing that, could I once produce conviction, there need be no country, however poor, that could not be traversed by profitable railways, I persevered, and to-day I find that my efforts have been crowned with a great and substantial success. Need I say that I appreciate this victory, counting the past pains as nothing, and being still more anxious to continue advocating the truth. But it is only due to this Association that I should state how much of my success I owe to its influence, and to the weight thus added to my now celebrated paper on "The Gauge for the Railways of the Future." To that paper I attribute a large proportion of the extraordinary activity that I have described. Stamped with the approval of this Association, the paper has circulated in all countries, and has been translated into all European languages, including those which have been naturalised in South America. It has formed the text for innumerable discussions; it is almost daily quoted in the journals of the United States; and it has excited the most lively interest among the railway engineers of that country, where existing railway management shows results still more discouraging than those which are obtained in England. The British Association, therefore, more than any other public body, has helped forward a vast reform, and gratefully feeling this, I am encouraged to come here again on this occasion. It is not long since, that to doubt established gauge was professional heresy. A type to which an accident had given birth, had come in course of time to be considered perfect; it was a superstition quickened into a religion. By degrees, after scores of thousands of miles of railway had been built, and hundreds of millions of pounds expended, it began to be seen that there was something still to be desired, and that it was ruinous to make railways for the service of remote districts yielding but small traffic, or in countries whose limited means and commerce could not justify large expenditure. By this time the great outlay which attended the labours of the earliest engineers—the outlay involved by heavy works to gain easy gradients—had been somewhat reduced, and with improved locomotive practice, steeper gradients and sharper curves became possible. Then came the very recent modification of making essentially light lines upon the standard gauge, conforming as much as possible to the natural coutour—surface lines, as I was the first to name them in 1864. By adopting them the cost of construction was greatly reduced, and was brought somewhat more into proportion with the revenue to be derived. But these improvements were but improvements upon a bad type, and real reform could not be effected whilst the width of gauge remained, while the rolling stock continued unaltered, and the locomotive rested unmodified. Meanwhile, the history of railway construction in England was slowly repeating itself, even in an exaggerated form, abroad, and particularly in our colonies, where the primitive types were perpetuated by the pupils of the old school of engineers. And here I may remark that the difficulties encountered in this country in railway reform have been faithfully repeated in our colonies—an illustration of cause and effect. Gradually it became know that the ruinous practice of English engineers in Norway had forced the government of that country to adopt an entirely new type, after the intermediate stage of light standard gauge railways had been largely tested and abandoned, and that for the first time a national narrow-gauge system was established. But this was done so quietly, and information filtered so slowly from isolated country, that until quite recently only a few have known of the change, and still fewer have known, or have cared to inquire, about the practice followed or the results obtained. Of course, exceptional and independent lines of very narrow

and New Zealand, narrow gauge railways have been undertaken, and gauge, established almost universally for mineral traffic, have existed for many years; but these, with the exception of the Festiniog Railway, do not enter into the question; on the contrary, indeed, their small traffic capacities, as worked, have served the opponents of narrow gauge as arguments against innovation. So matters stood when I, having convinced myself of the monstrous errors which cripple our standard railway system, and having learnt the capabilities of narrow gauge—which are yet scarcely understood even by the engineers who are advocating and constructing them—so matters stood when I first devoted myself to the effort of promoting the general introduction of narrow-gauge lines, and had the audacity to set myself up in opposition to long-established and deeply-rooted principles. At first the utmost concession I could obtain—a concession granted but by a few—was that for new countries, where railways did not exist, or for poor countries, where traffic was light and uncertain, a narrow-gauge system might be adopted with some amount of advantage; but that its capacity and consequent utility were proportioned to its gauge; and that hence, as a natural consequence, not only must such lines as I recommended be located in districts where only a very small business actually existed, but where also the prospects of its increase were extremely remote. I knew the error of this opinion, for I knew the actual capacity of narrow-gauge railways under proper management; therefore I was encouraged to persevere until, as the circle of conviction widened, I was enabled to put my views to the test of actual and wide experience, and to stir into life the radical reform which to-day is spreading on every side, and which shall before long become general.

I showed you last year how, upon a railway costing one-third less than a line of an ordinary gauge, I could with equal despatch carry such a traffic as that of the London and North-Western Railway, with a saving of three-fifths of the dead load carried; and how in so doing I could effect a corresponding reduction in engine power, and consequently in cost of fuel, of rolling stock, of engine repairs, and of maintainence of permanent way. All this could be effected at a speed at least equal to the present speed of freight trains for the goods traffic, and at 35 miles an hour for the passenger traffic; a rate which is but little below the average of the mileage made by fast passenger trains in this country. We are so accustomed to the present condition of things—or, perhaps, we are so ignorant of the real elements of railway economy—that it is difficult to believe this great reform possible, but belief was more difficult a year ago than it has since become, now that all my statements have been proved to be incontrovertibly true. The question, however, is one of such radical importance, that I may once more devote a few words to its elucidation. On the London and North-Western Railway the average practice is to employ 7 tons of waggon to carry 1 ton of goods, but I assume the proportion of dead weight to be only four to one, in order to make out as favourable a case as possible. The average weight of goods train on the London and North-Western Railway is 250 tons; composed, in the proportions I have mentioned, of 50 tons of freight to 200 tons of rolling stock. (See diagram E E) On the Livny (New Russian), (See diagram D D) 3ft. 6in. Railway, on the other hand, the average gross weight of trains is 354 tons, or 104 tons more than that of the London and North-Western, while the dead weight is only 94 tons. This proportion is also shown on the diagram. To carry this paying load of 260 tons on the London and North-Western, 1040 tons of waggons would be employed, or more than eleven times the weight required by my system. In all my arguments, I of course deal with general goods traffic only, exclusive of minerals. It may be urged against this comparision that the more favourable traffic conditions of the Livny Railway help the results; but it is sufficient to reply, first, that with the reduced gauge reduced weight of waggons in proportion to capacity is feasible; next, that the smaller waggon capacity is essential to economy; and third, that while rolling stock of the smaller class is certain to be loaded more nearly to its ultimate limits, the difference between the maximum load, and the absolute loads obtained in practice, are attended with none of the excessive cost inevitable on a 4ft. 8½in. gauge. I would here call your attention to a most important fact in connection with railway goods' traffic. The average load of merchandize carried by each waggon in this country is considerably less than 1 ton. Experience has proved that the exigencies of traffic in this country have settled this average, yet waggons of four times this capacity must nevertheless be provided. This fact of itself is sufficient to show that so broad a gauge as the standard one is very excessive. With a narrow gauge this evil may be prevented, and if a higher average per waggon could not be attained, at leat a far lower proportion of dead weight would result. This I have endeavoured to make apparent in the diagrams, which show the average proportions of dead to paying weight on the 4ft. 8½in. gauge, and on the 3ft. gauge; and I have also placed the load carried as the average by the standard gauge upon a train running on a 3ft gauge, the varying proportions being well expressed by contrasted colours. The great economy in working, brought about by the causes enumerated above, would react upon railway business, and in increasing it would certainly raise the waggon average, because the cost of carriage would be so much reduced. I think you will agree with me that I am no visionary, but have always spoken within the mark, making my position sure as I advanced, and asserting nothing that I could not prove in actual practice. I have obtained, by the development of my system, results very closely approximating to those I stated last year—namely, three to one of paying to dead load, and I know that this proportion can and will be reached when my views are fully carried out, when a Fairlie gauge is worked with Fairlie locomotives and stock; while by no other system in existence can such results be obtained. In the report of the Royal Railways' Commission, published in 1867, the following pregnant conclusions were arrived at from the opinions of the principal engineers and railway managers in this country: "The only way in which an increased receipt in proportion to the cost of running the trains can be anticipated, is in carrying a larger number of passengers in proportion to the number of passenger carriages in the train, and running the goods' trucks full instead of partially full; or, in other words, obtaining a greater amount of work out of the engines and carriages than at present. But this means that the passenger trains would be less frequent and more crowded; that the passengers going on to branch lines would have to change carriages more frequently; and that goods would have to be retained until full truck-loads were made up, which would result in a slower delivery of goods." So that, as the necessities of traffic enforce frequent passenger trains, three or four times the necessary weight of carriages must be provided, and as goods cannot be detained until trucks are fully loaded, it follows that universal extravagance is inseparable from the present system. Railway managers, who are of course thoroughly conversant with the subject, agree that our existing railways are at present being worked to the best advantage. If so, it cannot be doubted that there is a grave blunder somewhere; and if this blunder is not to be discovered in management we must seek for it in construction, and there we shall find it. We shall find that railways of the existing gauge will labour under disadvantage for all time; they will remain oppressed by the curse of dead weight, an evil from which they can by no means be relieved; dead weight in their rolling stock for passengers, one ton of which requires thirty tons to convey it; dead weight in their rolling stock for freight, which can never be more than one quarter fully loaded, and dead weight in their locomotives, ill applied for obtaining useful results, but always destructive to the permanent way. Nor does increase of traffic upon a great standard-railway system tend to reduce this evil; if it did, the London and North-Western Railway would not at the present time be expending enormous sums in doubling their permanent way. Experience shows that increased traffic does not diminish averages of weight; for the fact that these averages were larger twenty years ago than they are at present, although the traffic had not then reached half its present dimensions, was simply because the waggons then averaged about a ton less in weight. With a double business, each waggon does carry twice the average amount that it carried twenty years ago; but twice the number of waggons then employed carry each their usual complement of a single ton. There is, therefore, no escape from the conclusion that the existing proportion of dead weight to paying weight upon a 4ft. 8½in. railway cannot be reduced, so long as the condition of things exist which guided the Railway Commission to its conclusions, but that it must remain a fixed quantity independent of increase of business on the line. I think no more striking illustration of the error of our present system can be conceived than is afforded by the daily practice of a magnificient Company like the London and North-Western Railway; who, at the present moment, be it remembered, have commenced to double the width of their road through press of business; yet who are sending out daily, and daily receiving, at Euston-square, some 4,400 passengers, in carriages which contain sitting accommodation for 13,500; and who carry their enormous freight in increments, averaging less than 1 ton, in waggons having six times that capacity. Imagine the amount of capital sunk before this result was obtained! Conceive the waste of engine power, the wear and tear of rolling stock, the destruction of permanent way, the cost of staff, all entailed by this curse of dead weight; and then imagine how easily all this unmechanical and unbusiness-like state of affairs might have been prevented by the simple adoption of a suitable rolling stock running on a suitable gauge! I am not for a moment advocating any radical change in our English railway system; that system has out-grown the season of radical reform, and we must make the best of it as it is; but I seek to prevent the repetition elsewhere of mistakes that have been so costly here. I want to prevent the unnecessary extension of a system that is palpably false, but which is not on that account the less strongly defended and protected. That our great error was known some years since to all thinking engineers, is shown by the quotation I just now made; Mr. G. P. Bidder stated before the Royal Commission: "That great economy may yet be obtained in the transport of minerals over long distances by means of railways laid out

under conditions admitting of very long trains being run." In this statement I find the very essence of the question at issue between myself and all conservative engineers; I find the necessity of reform acknowledged, and the means of attaining it hinted at by my warmest opponent. Except that his views did not extend to passengers and goods, but were confined simply to tho transport of mineral traffic, we have a complete statement of the problem which I have brought successfully to a solution. The requirements which Mr. Bidder hinted at generally, I have worked out in detail, and have extensively reduced to practice, with results that show his judgement to have been sound as far as it went. The conditions under which a railway should be laid out to meet these requirements are clearly not those which rule the present system; ample experience proves the contrary, showing that no line, however full of business, can be worked to its full capacity. We are led, then, unmistakeably, to a narrow gauge, to the adoption of passenger carriages which shall be filled, of waggons which shall be almost fully loaded, and of weight which shall bear a reasonable proportion to their capacity, and we are led to the adoption of very long trains and powerful engines. Considering the date of Mr. Bidder's opinions, they could not have been put more clearly or more concisely. To a certain extent, but in a very limited and impefect degree, experiments were made in the direction indicated—faint foreshadowings of the practice now being so widely introduced—by an attempt to convey extremely heavy trains by means of an auxiliary pair of cylinders placed under the tender of the engine and receiving steam from the boiler; the idea being to utilize all the available weight of engine and tender for adhesion. In running expenses, the results of these trials were very satisfactory, showing a large reduction of cost in carrying the heavier load. There were many reasons why this arrangement should prove unsatisfactory, but I quote the results obtained, because they will not be called in question, and because if so much economy could be obtained by such a contrivance as the steam tender, I may at least claim proportionately advantageous results for the system of which this was an indication. Thus, with an ordinary engine, the cost of conveying a load of 210 tons 20d. per mile, whilst the cost of conveying a load of 310 tons by the aid of the steam tender was only 23d. per mile. It is obvious that no such saving as this could have been affected had two independent engines been employed upon the same duty. The results clearly prove that a large saving can be effected by increased engine power and greater loads; but, as I have already pointed out, this economy cannot be realized on railways of the standard gauge: but on the many thousand miles of narrow-gauge railways that will before many years be constructed, the true system of economical working, developed by me, will not only be possible, but will be universally acknowleged and adopted. It would seem a very simple and self-evident fact that the means of conveyance should be fairly proportioned to the amount to be conveyed, and yet I have been labouring for years to make people understand this. One would think it would be sufficient to point out, to countries contemplating the construction or the great extension of railways, and looking to England and English practice as a model, that the best labours of our engineers, after thirty years' experience, have given us a railway system on which it is necessary to have 4 tons of waggon for every ton of goods, and from 10 to 30 tons of carriages (see the diagram G) for every ton of passengers. And indeed abroad it is pretty widely understood that it can only be on a narrow-gauge railway that a full measure

Diagrams showing Proportion of Dead Weight to Paying Load in Railway Rolling Stock.

[The foregoing diagrams represent various proportions between dead weight and paying load, on railway rolling stock, as follows:—

A shows the average load carried in daily practice by the fairlie engine "Little Wonder" over the Festiniog Railway, 1ft. 11½in. guage, the average up grado being 1 in 92. The engine weighs 19½ tons, the weight of load is over 107 tons, and the proportion of paying to non-paying load s 3 to 1.

B shows tho average daily working of tho ordinary engine, weighing 10 tons. The load carried is a little in excess of 43 tons.

[The above diagrams show very clearly the capacities of the Festiniog Railway after and before the adoption of tho Fairlie engines on it.]

C shows the maximum load of 120 tons carried by tho most powerful engines on the 3ft, 6in. Norwegian Railway up gradients of 1 in 90. Tho proportion of paying to dead weight is 1.6 to 1.

D represents the daily working of tho freight train of The Imperial (Russian) Livny Railway, 3ft. 6in. guage, up gradients of 1 in 80. Tho gross load conveyed (exclusive of engine) is 354 tons, of which 260 tons are paying weight. The engine weighs 42 tons, and the proportion of paying and non-paying loads is 2.78 to 1.

E represents the actual ratio between dead and paying loads conveyed in a 250-ton goods' train on the 4ft. 8½in. gauge; the lighter tint indicating the maximum capacity of tho stock, giving 1.8 to 1 of paying to dead weight.

F shows the weight of a train on tho 3ft. gaugo carrying the same paying load, 50 tons, as that conveyed by the waggons on the 4ft. 8½in. gauge, as shown in tho previous diagram.

G is a diagram showing the existing ratio, between dead and paying weight, on passengers' train, 4ft. 8½in. gaugo, as well as its maximum capaoity, being 30 to 1 and 3.3 to 1 respectively

J I H aro diagrams showing the comparativo dead weights of trains on tho 4ft. 8½in., 3ft. 6in., and 3ft. gauges respectively, employed to carry 50 tons of paying load, every waggon of each train being loaded up to the present average weight of 1 ton per waggon.]

of usefulness can be obtained, and a proper proportion between paying and non-paying load can be secured;—this is because the amount of engine power being unlimited, better paying trains can be carried on the narrow than on the broad gauge; the difference arising from the fact that the dead weight required for the transport of passengers and goods is reduced in the manner shown by practice and indicated in the diagram. The reform is effected by the adoption of a suitable rolling stock, in which dead weight is kept down by the smallness of the gauge, but in which ample capacity is obtained. Such carriages and waggons exactly meet the difficulty which is one of the great causes of dead weight on a 4ft. 8½in. gauge—namely, the necessity of transmitting passengers and goods, whenever practicable, to their destination without change of vehicles. With the small carriages and waggons, the expense attending this proceeding is reduced to the lowest possible cost, because, though vehicles of appropriate capacity can be employed, and each can be loaded almost to its full complement of passengers or goods, carriages half or two-thirds empty would never form necessary accompaniments to a train; and even if it were not possible in practice to place a larger share of the load in each vehicle than the present average, we should have waggons of 5 tons capacity weighing 1½ tons, instead of others weighing 4 tons to carry the 1 ton average. This capability of subdivision of traffic is one of the most important advantages which the narrow gauge offers; it involves the leading principle in railway economy, but it is an economy which I have shown—and I am borne out by all the weight of the evidence given before the Royal Commission—to be impossible on the broad gauge. But it must be remembered—and this is a point not understood by some of the strongest advocates of narrow gauge—that such lines are of but little avail, unless they are provided with suitable locomotive power. If a line is made in all respects a miniature copy of a broad-gauge railway, with miniature rolling stock and miniature engines, its utility decreases, and its working capacity goes down, but its working expenses go up. In illustration of this I may quote the results of Norwegian practice, where one of the narrow gauge lines, carrying only a very small traffic as compared with that conveyed upon a broad gauge in the same country, shows its expenses to be out of all proportion; while the percentages of the expenses to the receipts vary from 65.47 to 103.5 on the various narrow-gauge lines now built in Norway, a result that cannot be considered favourable. If we look at the capacity of the engines on these railways, we shall see that they are capable of drawing, besides their own weight, 83 tons, 55 tons, and 84 tons respectfully, up gradients of 1 in 70, 1 in 42, and 1 in 60, and it is worth noting that the proportion of working expenses to receipts decreases as the power of the engine increases. Although many other causes besides those of mere locomotive expenditure step in to interfere with results, the regular proportion is I think, too clearly marked to be independent of this most important question. The capacities of the Norwegian stock and the maximum trains conveyed by the engines are shown in the diagram. I refer again for a moment to the results obtained by the employment of the steam-tender for dragging great loads. Mr. Sturrock found that he could, by adding a pair of steam cylinders to the tender of a locomotive, convey trains weighing one-half as much again as the maximum load carried by ordinary engines, with an extra expenditure of about 15 per cent.; and a train of any given weight can be conveyed for from 64 to 70 per cent. of the cost of such train divided into two equal parts, which means a saving in the locomotive accounts of from 30 to 36 per cent. It is argued against me that an engine of my system is no more useful or profitable than two engines coupled together. My experience proves the contrary; so far as they go, the results with Mr. Sturrock's contrivance bear me out, and so do the results obtained by the working of MM. Meyer's engines (adapted from my own) in France. If such a system as that which I recommend had been introduced into Norway, it is needless to point out that a considerable modification of the balance-sheet would have been the result. To sum up, then, the requirements necessary for making a narrow-gauge railway perfectly efficient, we must have light, small stock, easily handled, and very powerful engines, capable of drawing heavy loads. The experience of the present year entirely bears out this assertion. We need only turn to the 3ft. 6in. Livny Railway in Russia, carrying regularly its 354 tons of train exclusive of engine, a duty accomplished by one Fairlie locomotive without distress to the permanent way, and up gradients, some of which are 1 in 80, of 4 or 5 miles in length, and with an economy shadowed forth long since by the crude appliances that were tried with a vague hope of achieving a similar result. Again, as already stated, the introduction of the same system on the Festiniog Railway avoided the necessity of doubling the line of rails (a work which was actually commenced so far as preliminaries were concerned), by more than doubling the utility of the single pair. The diagrams show the change very strikingly, the one indicating the daily duty of the "Little Wonder," the other the similar duty of the ordinary engines of rather more the half the weight. It now remains to point out as briefly as possible the circumstances that have led me to adopt a 3ft. gauge, and to recommend that width for general introduction. Experience has shown that 3ft. 6in. can be made a highly economical and efficient width. but it does not by any means follow that it is the most serviceable and most efficient, any more than it follows that the accidental 4ft. 8½in. was all that could be desired, even though an Act of Parliament had made it an article of belief. On the contrary, as our knowledge and experience increase, we are enabled to approach more and more nearly to that happy mean, on either side of which is error. While, on the one hand, there is every necessity for obtaining such a gauge as will afford a good and useful width of vehicles, on the other it is necessary to avoid such narrow limits as would necessitate the introduction of too great overhang on each side of the rails. The 3ft. gauge appears to me to comply with all the necessary conditions better than any other, and it is from no mere theorising that I lend all the influence I have towards its adoption. There is a certain amount of saving in first cost as compared with the 3ft. 6in., not a large amount, but worth considering. This however, I leave out of the discussion for the present. The all-important matters are to place upon the rails a thoroughly efficient stock that shall posssess a maximum of capacity and a minimum of weight, and to supply engine power under the most economical circumstances, and I hold it to be easier to accomplish these objects on the 3ft. gauge than upon any other. I am led to this conclusion both by a comparison of the actual work done on the 3ft. 6in. gauge, with that which can be accomplished with the 3ft. gauge, and because, having in view the practical requirements of goods traffic, I find that I can obtain an ample floor area with less dead weight than can be secured by any other width, on a wider gauge the dead weight increases, on a narrower one the capacity diminishes. A statement of the actual results of comparison will explain this more clearly and more quickly than could be done otherwise. On the Queensland 3ft. 6in. Railway, the composite passenger carriages are 6ft. 6in. wide and 6ft. high inside, The capacity is equal to 34 persons, and the weight is 10 tons 5 cwt., or 6 cwt. per passenger; the second and third class carriages accommodate 48 persons, and weigh 9 tons 2 cwt., or 3.75 cwt. per passenger. The waggons average 14ft. in length, 6 feet in width, and weigh 3 tons 5 cwt. The covered waggons are 6 feet high inside, and the open waggons have sides 30 in. high, the first would have a capacity of about 7 tons, the latter of about 5 tons, the respective proportions of paying load to weight being 2.15 to 1, and 1.54 to 1. On the Norwegian 3ft. 6in. lines, the first-class carriages are 6ft. 10in. wide outside and 20ft. long, weigh 4.6 tons, and carry 32 passengers, the proportion of weight per passenger being 2.9 cwt.; the second-class carriages have the same length and width, carry 32 persons, and weigh 2.4 cwt. per passenger. The covered goods waggons are 18ft. long, 6ft. 7in. wide outside, weigh 3.7 tons, and carry 5 tons, the proportion of freight per ton weight of waggon being 1.2; this proportion is steadily maintained throughout the waggon stock, rising, however, as high as 1.6 to 1, while some of the more recent stock carries 6 tons instead of 5; of the increase of dead weight in these I have no data.

For a 3ft. gauge, the stock that I construct is as follows: for first-class passengers the carriages are 18ft. 6in. long, 6ft. 8in. wide inside, seating 18 passengers, and weighing 3 tons 5 cwt., or 3.6 cwt. per passenger. For second-class, the carriages are 16ft. 6in. long, 6ft. 8in. wide, weighing 3 tons, and carrying 24 passengers, being 2.5 cwt. per passenger; the third-class carriages are of similar size, but seat 30 people, the dead weight being 2 cwt. per passenger. It will be noticed that these proportions are nearly identical with those on the Norwegian lines, but considerably less than those of the Queensland Railway.* My open waggons are 10ft. by 6ft. 6in. by 2ft. 10½in. high, weighing 28 cwt. 3 qrs., and having a cubic capacity of 4 tons, equal to a proportion of 3 to 1; also others for light goods, such as cotton, are 14ft. by 6ft. 6in., with posts and rails 6ft. 6in. high from floor, or, as we are now running them in Mexico, with a low ledge running all round only 6in. high, on which cotton bales are piled in a similar manner to that on a street waggon or Lorry and covered with tarpaulin. The covered waggons are 10ft. by 6ft. 6in. by 6ft. of 360ft. contents, and weighing 33 cwt., equal to 3 tons of carrying capacity to 1 of dead load. In all this stock, as well as in the other classes required, the centre of gravity is kept low, and an angle of stability of 38° is in all cases maintained. It will thus be seen that upon a 3ft. gauge I am enabled to place stock of ample size and of less weight than can be done on the 3ft. 6in. lines. In adopting this stock, I secure several advantages inseparable from the Fairlie gauge. The principal of these are: the reduced widths between the sole bars for the under frames of waggons and carriages, and lengths of wheel centres, these in turn affect the scantlings of material, the weight of the wheels, the size of axles, to carry certain loads. It has been argued that the excess of strength over the actual requirements for carrying, but

* The stock here described is on the type used in this country; a different type would require to be made to suit different tastes, as in America for instance, carriages should have a central passage and rest on two bogies or trucks, with entrances at each end.

necessary to resist the shocks and eoncussions incident npon shunting, &c., would not be affected by the gauge; and that if the gross weight of a train is maintained upon the narrow, that is now worked on the broad gauge, the waggon frame and couplings must be alike in weight to give equal strength to withstand sndden shocks and strains. Of course this is in itself quite trne, and certain parts must be as strong in a train of given weight on a narrow as on a broad gauge. The force of the argument falls to the ground, if we remember that nnder present circumstauces an average goods train, say of 250 tons, has only 50 tons of paying weight, the remaining 200 tons being stock. Now, on the narrow gange, supposing that only one ton of goods was carried per truck, as in the case of the 4ft. 8½iu. gange, the dead weight required to carry it on my system would be only 87½ tons, making the total weight little more than half, and reducing the force of shocks upon the train in a proportionate manner, so as eonseqnently to rednce the requisite weight of parts. Take, now, this same weight of paying load in a train, namely, 50 tons, and place it in the same portions in the waggons of the Norwegian 3ft. 6in. line, or in those of the Queensland Railway, and wo shall find that the dead load carried runs up to 185 tons, or a close approximation to our English practice. Probably, therefore, this stock as built is not too heavy to resist the strains and shocks thrown upon it by reason of its own weight; bnt by the mode of coupling employed on the Fairlie stock, the destruction arising from the shocks caused by sudden stopping and starting of the trains, especially when shunting, is entirely avoided, and as the strength and eousequent weight of the prosent stock depends on the necessity of resisting these shocks and bumps, it follows that the instant these are removed, the neoessity for all this extra strength and weight is removed also. The foregoing figures really mean that to carry 50 tons of goods on the Norwegian or Queensland 3ft. 6in. gange, the proportion of 1 ton per waggon being preserved, 92 per cent. of the weight of rolling stock used on the 4ft. 8½iu. would be required; as against only 43 per cent. on a 3ft. gange; showing a saving of 47 per cent. on the latter as compared with the 3ft. 6in., as shown in the diagram. Of course, if the waggons were loaded np to full capacity, these perceutages would be very much changed. It is to this point especially that I wish to direct your attention, as upon it the economy of the 3ft. gauge rests. Whatever saving may be effected in first cost may be lost sight of, the great advantage lying in the saving effected in working expenses. Every ton of dead weight saved goes towards secnring the prosperity of the line, and if we can obtain the ample platform which the 3ft. gange gives, combined with so much saving in weight, there is nothing left to be desired. In makiug my comparison, I have taken matters as they exist in Queensland and in Norway. The able engineers of those lines have designed their stock as economically as they found possible. I should have thonght the dead weight might have been reduced to a certain degree; but of course I am aware that no snch reduction as may be made on a 3ft. gauge conld be achieved.

Before I conclnde, I may refer to one or two prevailing errors which exist with regard to the narrow gange, and which are often urged against it. It is said that with a 3ft. or 3ft. 6in. gange, a far larger amount of siding and goods shed accommodation is required. Is it not sufficient to point out, as the waggons earrying the same amount on the latter as on a wide gange are but some 10ft. long as compared to 16ft. that a train of the former, conveying the same loads as one on the latter, would have but ⅝ths of its length? Here, again, the axiom of subdivision of traffic is applicable in all its force.

Again, a common notion—and one that was strongly urged when the discnssion concerning India was in progress—is that narrow-gange railways may be construeted in diffieult and hilly countries, bnt not on level and favourable ground. Doubtless this idea has grown from the fact that the saving of construetion in the former localities is greater than in the latter. Bnt, as I have already stated, the economy in the cost of construction is altogether snbordinate to the greater aud constant economy in daily nse. The fact is that narrow-gaugo lines are useful everywhere, are needed everywhere; the saving in their first eost rises and falls with the country over which they pass, and, always considerable, is greatest where precipitous districts demand lines that creep aronnd and up hillsides; but the subseqnent economy is not variable; it is always what I havo shown it to be, when narrow-gauge railways and their equipments are worked, as everything shonld be workod, with a view to progress and development.

INSTITUTION OF CIVIL ENGINEERS.

SUBJECTS FOR PAPERS.—Session 1871-72.

The council of the Institntion of Civil Engineers invito commnnications on the subjects comprised in the following list, as well as npon others; such as—(a) Authentic details of the progress of any work in eivil engineering, as far as absolutely executed (Smeaton's account of the Edystone Lightbouse may be taken as an example); (b) Descriptions of engines and machines of various kinds; (c) Practioal essays on subjects connected with engineering, as, for instance, metallurgy; or, (d) Details and results of experiments or Observations connected with engineering science aud practice.

For approved original communications, the conncil will be prepared to award the premiums arising out of special fnnds devoted for the purpose.

1. On the application of graphic methods in the solution of engineering problems; 2. An experimental inquiry into the strains npon arched ribs, variously loaded, to ascertain the agreement between Calculation and experiment; 3. On the methods of constructing the foundation of some of the principal Bridges in Holland and in the United States; 4. On the oonstruction of bridges of large span, considered with special reference to examples, now in progress or recently completed, in the United States; 5. On the most suitable materials for, and the best mode of forming, the surfaces of the streets of large towns; 6. On the advantagos and disadvantages of subways, for gas aud water mains, and for other similar purposes; 7. On the theory and practical design of retaining walls; 8. On the comparative efficiency of different steam and hydraulic cranes, and on the application of steam power in the execution of public works; 9. On the different systems of road traction engines, with details of the results in each case; 10. On the nse of concrete, or bèton, in large masses, for harbour works and for monolithic structures; 11. On dredging machinery, with details of the cost of raising and depositing the material; 12. On excavating by machinery, with a description of any excavating machines which have been bronght into snccessful practical use; 13. On the various appliances and methods used in rock-boring and blasting, in this conntry and abroad, with details of the results obtained; 14. On explosives, as applied to industrial purposes, partieularly nitro-glyccrine, dynamite, and 'lithofraotenr; 15, On the gange of railways; 16. On economical railway construction and working; 17. On the systems of fixed signals, aud the connection between signals and points, at present in use ou railways; 18. On the details of construction of modern locomotive engines, designed with a view to economy, durability, and facility of repair, with particulars of the dnty performed, of the cost of repairs, &c.; 19. On tho best descriptions of oontinnons breaks, which have been extensively employed on railways, and the general resnlts of their working, both upon iuclined planes and upon levels; and on the use of cast iron, wood, and other materials for break-blocks; 20. On the best method of utilizing the resistance of the piston, as a retarding break power on railways; 21. On street railways, and the best mode of working them; 22. On the water supply of towns, including a description of the sources of snpply, of the different modes of collecting and filtering water, of the various incidental works, of the distribution to the eonsnmers, aud of the general resnlts; 23. On the theory and practical design of pumps, and other machines for raising water; as well as of turbines, and of water pressing engines; 24. On the employment of steam power in agricnlture. 25. On the theory and practice of the modern methods of warming and ventilating large buildings; 26. On the laws governing the flow of steam and other gases in pipes, and on experiments to determine these laws; 27. On the best practical use of steam in steam engines, and the effects of the varions modes of producing condensation; 28. On the rosults of the best modern practice in marine engineering, having regard particularly to economy of working expenses, by superheating, surface condensing, great expansion, high pressure, &c.; 29. On mechanical appliances, worked by steam, for use on board ship, as substitutes for mannal labour, in loading and discharging eargo, in raising the anchor, in working the sails, &c.; 30. On the design and eonstruction of gas works, with a view to the manufacture of gas of high illnminating power, free from suphur componnds, especially sulphide of carbon; and on the most economical system of distribution of gas, and the best modes of illumination in streets and buildings; 31. On tho maintainence, by sluicing, of the harbours on the coasts of France, Belgium, and Holland; 32. On the sea works at the mouth of the river Maas, and the effects produced thereby; 33. On the constrnction of tidal, or other dams, in a constant, or variable depth of water; and ou the use of cast and wrought iron in their constrnction; 34. On steel, and its present position as regards production aud application; 35. On the safe working strength of cast and malloable iron and steel, including the results of experiments on the elastic limit of long bars of iron, on the rato of decay by rusting, on the effect of vibration or prolonged fatigue on the strength of railway axles, chains, shafts, &c., and on tho relative extension and compression of wronght iron and steel nnder oqnal loads within the elastic limit; 36. On the means in nso for sinking doep shafts through quick-sands, or other shifting material; 37, On the various methods of draining distant isolated sections of mines; 38. On tho best forms of air-eompressing machinery and of hydraulic engines for conveying motive power to deep workings in minos; 39. On tho thoory and practico of the methods in nso for the artificial ventilation of coal and metallic mines; 40. On the washing of small coal, and the manufacture of artificial fuel; 41. On the

preparation and utilization of peat, and the machinery connected therewith; 42. On the systems and apparatus at present used in telegraphy; 43. On the pneumatic transmission of heavy trains through tunnels, and of light weights through pipes, with a comparison between the economy of the two systems.

The Council will not consider themselves bound to award any premium, should the communication not be of adequate merit; but they will award more than one premium, should there be several deserving communications on the same subject. It is to be understood that, in awarding the premiums, no distinction will be made between communications received from a member or an associate of the Institution, or from any other person, whether a native or a foreigner.

The communications should be written in the impersonal pronoun, and be legibly transcribed on foolscap paper, on the one side only, leaving a sufficient margin on the left side, in order that the sheets may be bound. A concise abstract must accompany every communication,

The drawings should be on mounted paper, and with as many details as may be necessary to illustrate the subject. Enlarged diagrams, to such a scale that they may be clearly visible when suspended on the walls of the theatre of Institution, at the time of reading the communication, should be sent for the illustration of any particular portions.

Papers which have been read at the meetings of other scientific societies, or have been published in any form, cannot be read at the Institution, nor be admitted to competition for the premiums.

The communications must be forwarded, on or before the 31st of December, 1871, to the house of the Institution, No. 25, Great George Street, Westminster, S.W., where copies of this paper, and any further information, may be obtained.

Charles Manby, Hon. Sec.
James Forrest, Sec.

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IRON AND STEEL INSTITUTE.

A DESCRIPTION OF THE AYRESOME IRON WORKS, MIDDLESBROUGH, WITH REMARKS UPON THE ALTERATIONS IN SIZE OF CLEVELAND FURNACES.

By Mr. John Gjers.

This paper was divided into two parts, the first having reference to the gradual increase in the size of the Cleveland blast furnaces. And the second part being a description of the Ayresome Iron-works, Middlesborough. The author stated that the credit of having proved that a considerable increase in the size of blast furnaces is practicable and may be of great advantage as a means of economising fuel is due to the iron smelters of Cleveland. The first blast furnace was built in Cleveland in 1851, by the late Mr. John Vaughan, who followed the practice of older districts, and made his furnace 42ft. high by 15ft. diameter at the bosh. Up to 1858 there was a gradual increase in size, the furnaces in that year being 56ft. in height by 16ft. bosh. The results of this increase in size were so satisfactory that Mr. Vaughan was led in that year to rebuild one of the Witton furnaces, and to increase their size from the original 42ft. by 13ft. to 61ft. high by 16ft. 4in. bosh. This may be said to be the first decided step towards the great increase in size which followed, the comparative results being so much in favour of the large furnace over the original small one that it soon became an undoubted fact that economy was to be found in that direction. Although the scientific reasons which led to a saving of fuel through an increase in size, were at that time not clearly understood, yet the practical results obtained were so beneficial that they culminated in that revolution unparalleled in the blast furnace history of any district, in which all the original furnaces were razed to the ground, and new ones on the now established improved principle were built in their stead. The author stated that the way in which this increase in size of furnace was carried out, together with numerous other improvements, reflected credit on the Cleveland ironmasters, and tested their enterprising spirit. The following table gives the furnaces in the order of their respective dates:

Date.	Name of Firm.	Number built.	Height.	Diameter of bosh.	Cubic capacity.
			ft. in.	ft. in.	
1851	Bolckow and Vaughan...	3	42 0	15 0	4,566
1853	Bell Brothers	6	47 6	16 6	6,174
1853	Bolckow and Vaughan...	6	54 0	15 0	7,116
1853	Gilkes, Wilson, Pease, and Co.	2	45 6	14 6	5,100
1854	Cochrane and Co..........	4	55 0	16 0	7,175
1854	B. Samuelson and Co,...	3	50 0	14 0	5,050
1854	Bolckow and Vaughan...	3	54 0	15 0	7,116
1854	Gilkes, Wilson, Pease, and Co.	2	55 0	14 6	6,800
1856	Stockton Furnace Co. ...	3	50 0	16 0	6,341
1856	Norton Iron Company...	3	50 0	15 0	6,000
1858	Thomas Vaughan.........	6	56 0	16 0	7,000
1858	Hopkins, Gilkes, and Co.	2	56 6	16 0	7,200
1858	Jones, Dunning, and Co.	0	58 0	17 0	8,000
1858	Bolckow and Vaughan...	1	61 0	16 4	7,960
1861	Gilkes, Wilson, Pease, and Co.	1	55 0	16 0	7,700
1861	Wm. Whitwell and Co...	3	60 0	20 0	12,778
1862	Bolckow and Vaughan...	2	75 0	16 6	11,985
1864	B. Samuelson and Co....	4	69 0	20 0	15,500
1864	Thomas Vaughan.........	3	70 0	18 0	12,000
1864	Lloyd and Co.	4	67 0	20 0	15,000
1864	Thomas Vaughan.........	6	81 0	19 0	16,000
1864	Stephenson, Jaques, and Co.	3	70 0	22 0	17,000
1865	Gilkes, Wilson, Pease, and Co.	2	75 0	21 0	17,700
1865	Bell Brothers	2	80 0	20 6	15,500
1865	Bolckow and Vaughan...	2	95 6	16 0	15,050
1866	Bolckow and Vaughan...	1	75 0	20 0	12,972
1866	Hopkins, Gilkes, and Co.	2	75 0	24 0	20,000
1866	Swan, Coates, and Co....	2	75 0	20 0	16,090
1866	Bell Brothers	2	80 0	17 0	11,500
1867	Norton Iron Company...	2	85 0	25 0	26,000
1867	Cochrane and Co..........	2	76 0	23 0	20,624
1868	Gilkes, Wilson, Pease, and Co.	1	75 0	24 0	22,500
1868	Stevenson, Jaques, and Co.	1	70 0	23 0	18,000
1868	B. Samuelson and Co....	1	69 0	21 6	16,000
1868	Lloyd and Co.	2	80 0	21 6	18,000
1868	Jones, Dunning, and Co.	3	73 0	18 0	12,000
1868	Bolckow, Vaughan, and Co.	2	95 6	22 0	25,940
1868	Bolckow, Vaughan, and Co.	1	95 6	23 0	28,800
1869	Thomas Vaughan.........	3	85 0	25 0	26,000
1870	Bell Brothers	4	80 0	25 0	25,000
1870	Stockton Furnace Co. ...	2	80 0	24 0	24,613
1870	Swan, Coates, and Co....	1	75 0	23 8	22,229
1870	Cochrane and Co..........	2	90 0	30 0	41,149
1870	Gilkes, Wilson, Pease, and Co.	2	85 0	27 0	32,000
1870	B. Samuelson and Co. ...	2	85 0	28 0	30,000
1871	Bolckow, Vaughan, and Co.	2 building	95 6	24 0	28,950
1871	Lackenby Iron Company	2 building	85 6	25 6	26,670
1871	Gjers, Mills, and Co. ...	2	85 0	25 0	26,000

It is worthy of notice that, with only one or two exceptions, there are now no furnaces remaining of all those but prior to 1859, so that practically, the present plants working in Cleveland date since then. The author stated that it was his opinion that the useful maximum of both height and diameter of bosh had already been attained, if not exceeded, and that there were already signs of a retrograde movement. The object of increasing the size of the Cleveland furnaces was twofold: first, to increase the make; and, secondly, to economise fuel; a third has followed gratuitously, namely, improvement in quality. The author believes that not much has been got from the first consideration; the saving in fuel, however, has been considerable, and may be put down at from seven to eight cwt. of coke per ton of iron made. The quality of the iron is also much improved, being more highly carbonised and more uniformly soft than it originally was. A great diversity of internal shapes exist in the

Cleveland furnaces, but this owing to each firm having been left to carry out their own ideas, and being unable to profit by the experience of their neighbours. In concluding this part of his paper the author observed that more settled ideas now prevailed with respect to the sizes of blast furnaces, and it is seen that mere cubic capacity is a mistake, as it is only in those furnaces where proper regard has been paid to the proportions and distribution of the materials charged, that the benefits from the increased size have been fully realized. The author commenced the descriptive part of his paper by stating that the Ayresome Iron works are built upon 32 acres of land, with a frontage to the river Tees of 330 yards. There are four furnaces, two of which have been in blast since the end of March this year; the second pair are expected to be ready for blowing in during the spring of next year. The whole of the minerals as they arrive are placed in the standage sidings, and are taken from that place by a four-wheeled tankengine as required over a 25 ton weighbridge, from thence they descend by the force of gravity to the lift; they are raised by pneumatic hoist to the top of the depôts, and afterwards tipped into the kilns and boxes respectively. The ironstone is calcined by a proportion of about one in twenty-five of small coal; this as well as the coke is filled into iron barrows, and after being weighed is sent up to the top, four barrows at a time, by the pneumatic lift. Each barrow carries 5 cwt. of coke, and from 12 cwt. to 13 cwt. of ironstone, the furnace charge being eight barrows of coke, eight of ironstone, and four of limestone. The furnaces are closed with the cup and cone arrangement, the gas being carried by down comer tubes into a culvert below ground, from whence it is distributed to the stoves and boilers. There are ten boilers of the plain cylindrical egg-ended shape, 60ft. long and 4ft. 6in. in diameter. The three engines are of the direct-acting vertical self-contained class, two of which are capable of blowing the four furnaces.

Connected with the works is a wharf now building, which will have a frontage of 210ft., and on it will be two four-ton travelling steam cranes. There are also the necessary repairing shops, consisting of smith's, joiner's, and fitting shops, with engine shed, store room, offices, &c. The furnaces are entirely built of fire-brick, the pillars and outer casing being built of common size inferior fire-brick, and the lining of best fire-brick, in lumps 24in. long by 6in. thick. The height of the furnaces is 85ft. At the widest part they are 25ft., and the hearth is 8ft. by 3ft. deep. Each furnace is blown with three tuyeres fixed in water plates in each breast, and the lower part of the hearth is surrounded with water-boxes bolted together. The author then proceeds to describe in detail the arrangement of the cast iron pipe stove introduced by him at this and other works; the calcining kiln, also devised by himself, and extensively used in many ironworks; likewise his furnace hoist on the pneumatic principle; concluding with a description of the boilers and a very fine set of blowing engines, which were built by Messrs. Cochrane, Grove & Co., of Middlesbrough.

ON FERRIE'S SELF-COKING BLAST FURNACE.

By Mr. I. Lowthian Bell.

The author stated that at the annual meeting of the Iron and Steel Institute, held in March, Mr. Ferrie described the construction of his furnace, and at the same time furnished an account of the ordinary work of this furnace compared with the results obtained in one of the furnaces of the Coltness Iron Company, working in the ordinary way. The advantage to be derived from the increased height of furnaces having been demonstrated in the North of England, it was natural to inquire how much of the economy obtained by Mr. Ferrie was due to the increase of height, and how much to the heat evolved by the combustion of a portion of the furnace gases in the flues. Mr. Bell stated at the previous meeting that whether the fuel used in the furnace were employed in the shape of coke or coal, it was not until it had assumed the former condition that its real work in smelting began; and he pointed out that, viewing the process in this manner, it appeared to him somewhat doubtful whether the advantage of Mr. Ferrie's system was not chiefly due to the addition made to the height of the furnace rather than to the self-coking portion of the range. He was led to entertain this opinion from the fact that, taking the quantity of coke in the coal actually used by Mr. Ferrie, it corresponded, after making the necessary allowance for his richer stone, with the fuel used by the author's firm, where the coal is used in its coked state. Within the last month the writer had been engaged in a series of estimates, in order to ascertain the precise nature of the heat evolution and appropriation in furnaces where the coal is used in its raw state, and these experiments have induced him to think that he was mistaken in the opinions expressed during the discussion upon Mr. Ferrie's paper. The author proceeded to demonstrate with much minuteness the precise amount of saving that is effected in the Ferrie furnace, and he came to the conclusion that half the saving of coal is due to the increase of height, and half to the combustion of the gases in the flues in the upper portion of the furnace. In this examination he confined himself entirely to an estimate of the actual evolution and appropriation of heat; but as he was informed that all previous attempts to economise fuel in Scotland by means of higher furnaces than those in general use at the present day failed, it is possible that the intervention of the structure forming the upper part of the coking furnace may be useful in the manner alluded to by Mr. Plum, by relieving a tender material of a portion of superincumbent weight. The author also alluded to the statement of Mr. Ferrie, to the effect that in his furnace there was an improved yield from the ironstone. Although the quantity stated by Mr. Ferrie seemed large, the results obtained by comparing Coltness with Monkland appeared conclusive, and, therefore, he agreed with Mr. Ferrie in thinking that the saving at the top of the furnace is the only way to account for the difference in yield mentioned by Mr. Ferrie and confirmed by the Coltness Company.

THE GEOLOGICAL FEATURES OF THE SOUTH-STAFFORDSHIRE COAL FIELD, IN SPECIAL REFERENCE TO ITS FUTURE DEVELOPMENT.

By Mr. Henry Johnson.

The writer observed, it was well known South Staffordshire was one of the oldest of the great mineral producing districts of Great Britain, for it was in the immediate vicinity of Dudley that Dud Dudley first demonstrated the practicability of smelting clay ironstone; and though the discovery was of no benefit to him, posterity had acknowledged the debt which the iron trade owed to one of the early masters, whilst the district had ever been famous for the production of iron. The South-Staffordshire coal-field in its virgin state was remarkably rich in coal, ironstone, and limestone, and from the position in which they lay and "cropped," they could not well escape observation. In concentration of wealth no part of Great Britain had presented such a striking example. Rich seams existed but a short distance from the surface, and the various minerals lay so close together that ironstone and coal were worked by one operation. The most valuable seam was the famous "thick," or ten yard coal, representing a deposit of carbonaceous matter, the equal of which was not to be found in any other coal-field in Great Britain. The enormous bed might be said to consist of numerous minor beds, with but little foreign matter intervening, except in the south, where there was a large clayey deposit separating the beds. (A section prepared by Mr. Henry Johnson was here shown, it was 32ft. in length, and gave the various beds in their proper thicknesses). All this was hard, fine, bright coal. The necessities of the local and other ironmasters, and the demand for domestic consumption, had led to a continuous extraction, and it must be admitted that the older portion of the Black Country was nearly worked out. Under these circumstances it was of vital importance to the district to ascertain how long the deposits were likely to last, and what were the prospects of following the coal measures underneath the red rocks which surrounded the coal-field. The object of the paper he had the honour to read was to give a sketch of the geological features of the district in special reference to the future extension of its resources. The composition of the rocks were igneous and aqueous; and of the latter, in ascending order, there were: the silurian, consisting of Wenlock and Ludlow series; (2) coal measures proper; (3) permean; (4) new red sandstone; (5) drift deposits. The former comprised masses of columnar basalt, interbedded trap, and decomposed intensive igneous rocks of various kinds. The South Staffordshire coal measures repose throughout the district upon a floor of silurian strata, which were brought to the surface in some places, and had been proved in deep sinkings below the coal in the centre of the district. Between Dudley and Wolverhampton there are a number of eminences, for the most part anticlinals of upper silurian strata, the strike of the beds being nearly north and south, in evidence of the lateral disturbance of the beds by faults. Dudley Castle, Wren's Nest, and Thurst Hills were composed of Wenlock limestone and shale, the former in two bands, and used in blast furnaces. These silurian strata occupied a nearly horizontal position underneath the central part of the coal-field, but gradually rose to the east, and in the neighbourhood of Walsall they "cropped" out. A few miles east of Walsall there were indications of lower members of silurian series than those mentioned. The Hay Head, or Barr limestone, was regarded as the equivalent of the Woolhope limestone of Herefordshire; and at Barr, and near Hay Head, a yellowish sandstone occurred, and that evidently corresponded with the Llandover sandstone. Further west, on the side of the coal-field, however, no silurian beds newer than the Wenlock series had been found. At Sedgley Beacon, about three miles south of Wolverhampton, the Wenlock beds were overlaid by the limestone and shales of the Ludlow rocks, and a small patch of the same formation was brought to the surface at the Hays, near Stourbridge. It was then evident that the coal measures rested upon the upper silurian deposit, though not conformably. There was an indication of a great break in the geological series, for there

was no trace of the different members of the old red sandstone, mountain limestone. aud Yoredale series, or of millstone grit, all of which ought to interveue between the silurian and the coal measures proper if the series were complete. It was assumed that from the close of the silurian period to the commencement of the formation of the coal measures proper a tract of silnrian country stretched across the central part of England, as it now is from east to west, and formed a large island iu the early seas. Thus the causes which sneccssfully operated in laying down the old red saudstone, mountain limestone, and millstone grit, had no effect on the dry land of that time. Later on however, the island was depressed, and the true coal measures deposited on it, and there was ample evidence to prove that the siluriau measnres had undergone much abrading action, and had in many places been partially removed previous to the deposition of the coal measures upon them.

The true coal measures attained in some parts of the field a thickness of about 1,000ft. and the area of the coal-field was from 110 to 120 square miles, extending from Cradley Park Colliery to the Brereton Colliery, near Rugeley, and from Bullock's Farm, West Bromwich, to Thinley. The various seams of coal and ironstone were not persistent, and very frequently changes took place within a comparatively short space, and thus it was not easy to correlate the beds either iu those existing in other coal-fields or in distant parts of the same field. Iu considering how far evidence of this kind might be made available in tracing a connection between the South Staffordshire and adjoining coal-fields, it was advisable that the foregoing fact should be remembered. The general character of the measures in the central, sonth; and north portions of the field were best illustrated by the sections given in the memoirs of the Geographical Society. They showed a total thickness of 90ft. From reliable information obtained by him (the reader) a few years ago, the average thickness of the thick coal worked np to that time was about 7½ yards thick of clean coal; but at the Clay Cross open work, near Coseley, it measures 12 yards 2ft. thick. Following the measures towards the north-east, the thick coal "cropped" out near Bilston and Wednesbury, and beyond this point up to the Bentley Trough fault the coal and ironstone underlying the thick coal increases in thickness and value; and to tho north of Bentley fault were the Cannock Chase measures, which were supposed to be a portion of thick coal deposited in varying thicknesses. In the sonthern portion of the field, from Park Head to the south, there was a gradual thickening of shales and sandstones, until it came to little better than a bed of mud nnder the pormeans, at Hagley, and South of Hales Owen. It was very difficult to account for the reduction of the finest bed of coal in the world to one that was valueless in the short distance of three miles.

The South Staffordshire coal-field might be divided into four districts, each having very singular and apparently fortuitous geological conditions:—(1) South central, where the thick coal—fine and thick—is free from partings, with nnder measnres thin and poor in quality; (2) north oentral, where the thick coal was wanting altogether, the under measures of both coal and ironstone being of fine quality, and nearly double the thickness as compared with the places where the thick coal exists; (3) extreme north, where the thick coal is absent as one bed, and the ironstones absent too, but where there were seams of coal of fine quality and great thickness; (4) the extreme south, where the thick coal is split up into numerous and separate beds of almost worthless character, together with a lack of ironstone. In the latter, however, there were two beds of pure fire-clay, counterbalancing the loss of the thiok coal of fine quality. To attempt to account for the seeming incongruities would take too long, bnt the subject was one of deep interest to the inquiring geologist.

Over the whole field the measures had been disturbed by "faults," among the most important being the great boundary faults at Russell's Hall, a down throw; at Dudley Port, down throw; at Brierley Hill, down throw; at Ball's Hill, np throw; and at Bentley, down throw. Igneous rocks are fonnd in various parts of the field, the most important mass being that of the Rowley Hills; there were also Barrow Hill and Park Hill. Intensive veins of trap rock were also numerous, and the coal had been altered by the contact. These rocks were supposed to belong to the carboniferous period, but they might be younger. Recent mining operations had thrown much light upon the basalt and the coal; and it had been clearly showned that the basalt was but a comparatively thin covering over the coal measures which lay in regular order beneath this rock, which appeared to have been forced upwards through a small opening or openings, and hvae spread itself over what was at that period dry land or the bottom of a shallow sea. (The reader here exhibited a section in support of the theory.) Thirty or forty years ago it was the general opinion that the coal conld not be found nnder the hills, or within a long distance; but experience had shown that some of the best coal in South Staffordshire had been discovered beneath them. The most remarkable event in the discovery was that in the sinking of Mr. Minton's new pits, a distance of 275 yards, no basalt was met with, although it was *in situ* high and columnar, within about fifty yards of the pit tops. The Earl of Dndley was also raising large quantities of coal from under the hills, althongh at Oakham ouo of tho pits was much disturbod by trap. Several squaro miles had been added to the aroa of tho field by the discovery.

The reader then described the great boundary faults, and argued that they were not supposed to cut off the coal measures, but simply to lower them a greater depth from the surface. Upon such an assumption there was reason to believe that coal would eventually be found on three, if not on all sides of the field, by penetrating the rocks; but it was, of course, impossible to say at what depth the coal would be found, or successfully worked. One of the first successful attempts to discover coal beneath the permains and new red sandstone in England was made by the Earl of Dartmouth at the Heath Colliery, West Bromwich, iu 1832. The thick coal of a large area was there discovered after years of difficult sinking through water-bearing works. This coal was worked to what was believed to be a down throw, but lately the belief that coal would be found nearer Ermingham gained ground, and twelve months ago a company called the Sandwell Park Colliery Company was formed to test the ground abont a mile and a-quarter west of the colliery alluded to. If the coal was discovered it would not only be a great acquisition to the wealth and property of the South-Staffordshire coal field, but it would not be nnreasonable to predict a connection between the coal-fields of Warwickshire and Sonth Staffordshire. The sinking at Sandwell had proceeded to a depth of 70 yards with perfect freedom from runniug sand, and very little water. Mr. Johnson here described the sinking operations, which have been described from time to time in these columns. Besides this sinking in the permeans there had been several lateral headways driven from the coal measures into the perman, con the down throw side of the western boundary fault, by the Earl of Dudley and others, but without a discovery of the amount of down throw. The ouly true test for that side of the coal-field was to sink a shaft in some favourable spot between the Shropshire coal-fields and the South Staffordshire; and it was to be regretted that the vast unexplored region lying between the two coal-fields did not possess sufficient landed and mining interest to put the suggestion to a practical test. A few years ago two important trial sinkings were commenced in the sonth end of the coal-field. The first was at Wassel Grove estate, near Hagley; but more than one party grew tired of it, and it was not until Messrs. Crampton took up tho matter that the fate of the district was decided. At a distance of 165 yards an inferior coal mixed with bat was reached. This represented the thick coal but was of no commercial value. The pit was ultimately sunk to 262 yards when the upper Ludlow beds were pierced, and this fact showed that the finding of coal was hopeless. The other important sinking was a few years ago commenced at Manor Farm, near Hales Owen, by John S. Dawes. This siuking after passing through an extra thickness of npper coal measures reached a bed of coal at a depth of 208 yards, of about 3ft. 6in. in thickness, and very extensive lateral explorations were being carried on with the hope of discovering the thick coal. This sinking at the depth of 420 yards pierced the upper Ludlow limestone beds. Recently, the West Cannock Colliery Company had discovered the shallow and deep coals of Cannock Chaso, at a depth to the deep coal of 307 yards. The sinking has gone through what the Ordnance map was pleased to call "Quartzose gravel, unconsolidated conglomerates, and the new sandstone," at a point beyond the predicted run of the great western boundary, and then speculation was rife as to the exact position of that fanlt in the north-west portion of the coal-field. A trial has recently been attempted at Huntingdon, bnt the affair had come to a dead lock. In all probability the most signal piece of good fortune which has befallen explorers of the confines of this coal-field is at Aldridge, where the proprietors of the Coppice Colliery, after working a series of upper coals and ironstones not very successfully, concluded to abandon the place; but, through the exertions of Mr. Lindop, the mining engineer of the company, a test of the ground was made, and at a depth of 450 yards the shallow and deep coal had been found sufficiently near to work together. Mr. Johnson said it would be difficult to indicate the importance of the discovery, as it would go far to connect the Aldridge district, not only with the Cannock Chase, but is strong evidence in support of a connection existing between the Sonth Staffordshire and Warwickshire coal-fields. The writer then referred to the ease with which the correlation of the South Staffordshire and Shropshire coals and ironstones could be made, and referred to the report of the Coal Commission just issued, "On theprobability of Finding Coal under the Permean and New Red Sandstone," and pointed out the fact of their having expressed a strong opinion in favour of the probabilities of coal being ultimately found between the two coal-fields. The report, the author said, was equally favonrable as to there being coal found nltimately between South Staffordshire coal-field, and he hoped the country may yet have to rejoice in the successfnl discovery of coal in these immense tracts of country referred to, which would enable South Staffordshire to hold her

prestige among the iron manufacturing centres of the kingdom, and the effort now made by the Iron and Steel Institute to further the object would not have been without its good resnlt

THE MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

(*Concluded from page* 201.)

EIGHT MORE LIVES SACRIFICED FROM THE NEGLECT OF ENCIRCLING HOOPS OR OTHER STRENGTHENING APPLIANCES FOR PREVENTING COLLAPSE.

No. 21 explosion was of a very disastrous character. It occurred at an iron works, at six o'clock on the evening of Wednesday, June 28th, killing as many as eight persons and injuring twenty others. The boiler was of plain cylindrical single flued construction, but the fire was placed underneath it, instead of inside, as in those of the Cornish class. Its length was considerable, being as mnch as 43ft.; its diameter in tho shell 6ft. 6in., and in the flue tube 3ft. as nearly as could be ascertained after the explosion, the thickness of the plates, both in the shell and the tube, being ⅜ths of an inch, while the pressure of steam at which the safety-valve blew off was 50lb on the square inch. The boiler gave way, as in No. 20 explosion just reported, in the flue tube, the tube collapsing laterally from end to end till the two sides came together. The flattening of the tube led to its rending asunder at four of the circumferential seams of rivets so that it was divided into five sections, added to which the front end of the boiler was wrenched away from the shell, and the back end torn in two pieces. The shell of the boiler was lifted from its seat and thrown to a distance of about thirty yards, while the sections of the tube were hurled, some as much as sixty yards, and others one hundred and ten yards. With regard to the cause of the collapse, the furnace tube, though of so gigantic a length as 43ft., and having a diameter of 3ft. and a thickness of plating of only ⅜ths of an inch, and being subjected to a pressure of 50lb on the square inch, was not strengthened as it should have been by any encircling hoops or other suitable provision to enable it to withstand external pressure. Under these circumstances it should not have been worked with steam exceeding 25lb on the square inch, while even at that pressure so long and large a flue tube should have had some strengthening appliances. It may be added that the tube was found on examination to be wasted by corrosion at several of the ring seams of rivets, which rendered it still weaker. But as the tube, if sound, would not have been safe at the pressure at which it was worked, the primary cause of the explosion was not the wasting of the plates by corrosion, but the omission of encircling hoops or other equally efficient means for enabling the tube to resist collapse. There are facts in the history of this boiler which are interesting. It appears that the boiler was made about the year 1865, and that from that time to quite recently it had worked with a series of three other boilers driving a condensing engine. Lately, however, a new non-condensing blast engine had been fixed at the works, for which two new high-pressure steam boilers were laid down, when, or shortly after, the boiler in question was removed from its connection with the low-pressure series, and set to work along with the high-pressure series, the steam in one case being about 25lb on the square inch, and in the other 50lb. Before the boiler was reset, the boiler maker belonging to the works gave it what he considered to be a complete overhaul. He put some new plates into the bottom of the shell, and some more into the ends, but replaced the tube without strengthening it with any encircling hoops, although that was the weakest part of the boiler, and although hoops of bridge rail section were adopted in the two new boilers alongside. The result was as already described. One morning about a fortnight after the boiler was set to work, when the steam was blowing off a little more violently than usual, the gauge standing at 50lb, whereas it generally stood at about 40lb or 45lb, the tube collapsed, killing the eight poor men already enumerated. At the inquest a scientific witness stated he considered that the flue, which was the weakest part of the boiler, was not safe at a higher pressure than 30lb on the square inch, and that when new and in good condition it would collapse at a pressure of about 50lb or 60lb. He thought it very probable that some dust had adhered to the plates in the flue, consequent on leakage at the seams, which prevented the boiler maker seeing any defects. He pointed out that the seams of rivets ran in line along each side of the flue from one end to the other, and objected strongly thereto. He is not reported however to have called attention to the omission of flanged seams, encircling hoops, or other suitable appliances for preventing collapse, though this omission was the primary cause of the explosion. The boiler maker belonging to the works who had had charge of the repairs, and been engaged as a boiler maker for the last twenty-five years, stated that the owners had instructed him to effect a thorough repair, to search out all the weak places, and make the boiler as good as a new one. This he had done to the best of his ability, and considered it was as good as new when it left his hands. Had he reported to the owners that the boiler was not safe, they would not have set it to work. The jury found as their verdict that the explosion was purely accidental, adding that they considered that the boiler maker had used the best of his skill, and therefore was not blameable, and also that the owners had used every precaution, and they were sure would never have had the boiler set to work had they not thought it was perfectly safe. However consolatory this verdict may be to the parties responsible for the catastrophe, the ugly fact remains that eight persons were killed and twenty others injured by the explosion, that explosion springing from a boiler owned by those who were stated to be too high-minded to have used it had they for a moment doubted its safety, and which was turned out by a boiler maker of twenty-five years' experience, who is said to have used the utmost of his skill. These facts should be read alongside of the Select Committee's statements that compulsory inspection would lessen the responsibility of the users, and that the users are best able to ascertain the condition of their boilers. The idea of the boiler owner's responsibility appears to be more ideal than practical, and it may be asked, what avail has it been in this case? Indeed, has it any existence? On the other hand it is certain that had the furnace tube in this boiler been strengthened with such appliances as are in vogue throughout the country, and which were adopted in the two boilers alongside, to which it was connected,—had these appliances been enforced by a system of compulsory inspection, the explosion would have been prevented, and the lives saved.

AN EXPLOSION ARISING FROM EXTERNAL CORROSION, WHICH WOULD HAVE BEEN DETECTED ON COMPETENT EXAMINATION.

No. 22 explosion, by which one man was injured but fortunately no one killed, occurred shortly after two o'clock on the afternoon of Tuesday, July 11th, at a charcoal grinder's. The boiler was of the ordinary Cornish class, having a single furnace tube running through it, though of very dumpy proportions, its length being only 7ft., while its diameter was 5ft. 6in. in the shell, and 3ft. 3in. as nearly as may be in the furnace tube, the thickness of plates in both being ⅜ths of an inch. What the pressure of steam was could not be ascertained after the explosion, but it is not of importance in this case. The boiler gave way in the external shell, which was constituted of only two belts of plating, the second rending primarily in an irregular longitudinal direction near to the bottom of the boiler, and then peeling away from the remainder of the shell, ripping round at the circumferential seam of rivets on each side, and opening out almost flat. On the occurrence of this rent, the boiler was thrown from its seat, the end wall of the premises blown to the ground, the chimney much shaken, and the safety-valve ball, weighing about 30lb, blown to a distance of about 300 yards, where it alighted on a dwelling-house used as a post-office, passing through the roof into the bedroom beneath, then through the bedroom floor into the room below that in which were two persons, one of whom, not a moment before had been standing in the precise position where the ball fell. Added to this, the owner of the boiler, who attended to it himself, was injured. An examination of the plates of the boiler left no doubt as to the cause of the explosion. The plates in the neighbourhood of the primary rent were so eaten away by external corrosion consequent on moisture, that they were reduced to the thickness of a sheet of paper, and the explosion is therefore attributed to the dilapidated state of the boiler. The boiler in other respects was in a very unsatisfactory condition, and had evidently been much neglected. The crown of the furnace tube was seriously distorted, being bulged down for a length of 2ft., the effect in all probability of overheating from shortness of water. This was an old defect, and yet the boiler was worked on. When it took place it appears to have strained the ring seams of rivets in the furnace tube, in consequence of which a bolted patch had been put on, but the bulging left as it was. Added to this the manhole, which was unguarded, showed serious signs of straining, and the shell was not far from rending at that part, when it would no doubt have given rise to an explosion as in other similar instances. Also there was another bolted patch and a hole stopped with a wooden plug, from which leakage had been evidently taking place. The boiler was altogether in a most discreditable condition. It seemed to threaten explosion at all points. This is another very suggestive explosion in connection with the statements in the Parliamentary Committee's report that compulsory inspection would lessen the responsibility of the user, and that he is best able to ascertain the condition of his boiler. In connection with this statement, the fact will not be lost sight of that in this case the owner attended to the boiler himself, and it will be questioned whether any threatened action for damages in the event of explosion would restrain a man inclined to neglect a boiler in the way that this boiler was neglected, and whether it is wise, for fear of interfering with the responsibility of such men, to leave them at large to jeopardise the lives of those living near them, and to wait till disaster actually occurs, and the time for prevention is past, before stepping in.

INSTITUTION OF ENGINEERS IN SCOTLAND.

ON THE TEMPERATURE AND ELASTICITY OF STEAM

By Mr. Alexander Morton.

The early experimenters on steam, and other physicists since their time, have cherished the hope that some simple law would be found to connect the temperature, pressure, and density of steam, and as the subject had occupied much of the writer's time he would now lay before them some results of his labours.

Until the publication of those beautifully accurate experiments of M. V. Regnault on the temperature and elasticity of steam, we were without a chart to guide us. Those experiments were entrusted to him at the expense and by order of the French Government (published in the "Mémoires de l'Académie des Sciences," 1847), and are now well-known to be the standard upon which mathematicians have laboured to find some simple formulæ which would include their whole range.

When such physicists as Gay Lussac, M. Biot, and M. Regnault, including, also, some of our greatest mathematicians, have devoted so much of their time to this subject, its importance need not be questioned. From some experiments of the writer, and others which he had studied, he had been, so to speak, impelled to attempt this problem, and he had now adopted a formula and deduced his constants from M. Reynault's experiments so satisfactory to himself, that he had prepared the annexed table to show the comparison between the formulæ and the "graphic curve" M. Regnault had given, and he hoped to be excused if, in pointing out the differences between his formulæ and those of others, he should inadvertently appear to undervalue their labours.

In calculating that table which M. Regnault has added as a summary of his experiments throughout their whole range, he found it necessary to make use of three distinct formulæ, neither of which could, with any degree of accuracy, be extended beyond the limits fixed by him. The first being from 32° below Centigrade zero to 0°, or freezing point; the second, from 0° to 100°, or boiling point; and the third from 100° to 230°. The third or last formula he terms "the unique formula (H)," and when compared with the "graphic curve" at the higher temperatures it is certainly very near; but at the freezing point and other low temperatures the difference of the logarithms is too great to warrant us in admitting such errors could have been overlooked by an experimenter of his experience and knowledge; hence the necessity for three distinct formulæ; moreover, these formulæ are not more simple than many which have been published since.

The most accurate formula, embracing the whole range of the curve, was published fully twenty years ago in the "Edinburgh New Philosophical Journal" for July, 1849, and from that time to the present the writer was not aware of any since published that could at all compare with it, either for range or accuracy. This formula had been suggested to its author by our esteemed expresident, Professor W. J. Macquorn Rankine, from his theoretical views on the action of heat; but that it is an absolute expression of the law, its deviation from the experiments at the lower temperatures leaves room for question.

Messrs. Fairbairn and Tate, in or about the year 1859, made a series of experiments with some very perfect experimental apparatus, with the view of determining the law of the density and expansion of steam, which formed the subject of a paper read at the British Association Meeting of that year; but these experiments having been subsequently extended and developed by these gentlemen, a full report was not made public until after the "Bakerian Lecture," May, 1862. In studying these experiments, and whilst comparing them with some he had made himself, with the view of defining the density of steam, the formula now under consideration, connecting the temperature and elasticity of steam, suggested itself to him, and to give them an idea of its accuracy he had prepared the large sheet now exhibited.

The first two columns give the temperatures in Cent. and Fah. degrees, from—32° to 230° Cent. The third column gives the pressure in pounds per square inch deduced from M. Regnault's "graphic curve" which is given by him in millimetres. The fourth column, also in pounds per square inch, has been calculated by the formula for the purpose of ready comparison. The fifth and sixth columns give the corresponding logarithms. He had added the last two columns in millimetres to show the differences more fully. Those pressures below the freezing point are copied from M. Regnault's summary table, and those above that point are copied from his table for the air thermometer, series H, page 608.

At—32° Cent. the pressure 0·320 millimetres is the lowest experimental point upon which he founds his first formula; at that point the formula under consideration gives 0·319 millimetres, differing only the one-thousandth of a millimetre. At the freezing point the difference becomes about one-seventieth of a millimetre; at the boiling point, about one-third of a millimetre; and at 210° Cent. or 410° Fah., the difference is only six millimetres in upwards of fourteen thousand.

The intermediate stages are equally near, often nearer, and as the formula by logarithms becomes simple addition and subtraction, he trusted both formula and table might be found useful hereafter. One very important element in this formula is the first term of the denominator ($\sqrt{t}\,t$), which expresses that the square root of the temperature is multiplied by the temperature itself. The form of the expression, as explained by Professor Rankine and others, is that which was adopted by Professor Roche, and differs greatly from that adoped by M. Biot and M. Regnault. It is much more simple, and this fact commends itself. Of all the formulæ which have been from time to time proposed he thought he had for the first time multiplied the square root of the temperature by the temperature itself, and he begged particular attention to that term. The zero point and constants which he had adopted were calculated to the best of his judgment from the standard experiments before named, and when the many corrections for different kinds of glass, pressure on the bulbs of the thermometers, &c., are taken into consideration, necessary in such delicate experiments, it is surprising how well they agree with the formula. For instance, at 250·0°; Cent. by the standard air thermometer, Choisy le Roi crystal gave 253·00°; ordinary glass gave 250·05°; green glass gave 251·85°; and Swedish glass gave 251·44°. There is another point to which he would direct attention; in the experiments tabulated by M. Regnault, those performed with the air thermometer, and those with the mercurial thermometer, agree exactly from—32° Cent. to the boiling point; but from that point upwards the pressure registered by the mercurial thermometer gradually declines until at the highest temperature, 230° Cent., or 446° Fah., the pressure registered is 20160·0 millimetres, whilst the air thermometer for the same temperature registers 20915·0 millimetres. Now, near as his formula agrees with the air thermometer experiments, unlike all other formulæ heretofore proposed, at the highest experimental temperature it gives a less pressure than that by the air thermometer, and a greater pressure than that indicated by the mercurial thermometer; whereas all other formulæ at that temperature give a greater pressure than that indicated by either the air or mercurial thermometer, and this is a very important difference, more especially if the formulæ be applied to higher temperatures than those of experiment.

Near the beginning of this paper I stated that M. Regnault, before being able to construct his general table, had necessarily to make use of three different formulæ. The three points of the curve given by experiment he chose for a basis for his first formula were—32°,—16°, and 0° Cent. Thus:—

Temperature. Centigrade.	Experiments. Millimetres.	Formula. Millimetres.	Difference. Millimetres.
—32	0·320	0·319	—0·001
—16	1·290	1·326	+0·036
0	4·600	4·586	—0·014

For the second formula experimental constants chosen by him were thus:—

Temperature. Centigrade.	Experiments. Millimetres.	Formula. Millimetres.	Difference. Millimetres.
0	4·600	4·586	— 0·014
+ 25	23·550	23·695	+ 0·065
50	91·989	92·210	+ 0·220
75	288·500	288·391	— 0·109
100	760·000	759·620	— 0·380

His third, or, as he terms it, "the unique formula (H)." is given in his summary table before referred to. This formula embraces the greatest range of the "graphic curve," fixed by experiment, and at the higher temperatures is certainly very near it; but when used in calculating the lower temperatures; as he had already explained, its deviation from the experiments is too great to come within the limits of error. For instance, at the freezing point it gives 4·48 millimetres pressure. Professor Rankine's formula gives 4·47 millimetres, whereas, by experiment, the pressure is 4·600 millimetres.

Formula.

$$\text{Log. } P = A - \frac{B}{\sqrt{t}\,t - at^2}$$

Value of the Constants.

$A = 6{\cdot}0962000$
$B = 60962{\cdot}00$ Log. $= 4{\cdot}7850592.$
$a = 0{\cdot}0012884$ " $= 2{\cdot}1100507.$
$t = 495{\cdot}4°$ plus temperature in degs. Fahrenheit.
or 527·4° below the freezing point.

Temperature and Pressure of Steam.

Comparison of M. V. Regnault's "Graphic Curve" with the Formula,

$$Log.\ P = A - \frac{B}{\sqrt{tt - at^2}}.$$

Temperature.		Pressure in lbs. per square inch.		Logarithms of the pressure in lbs. per square inch.		Pressure in millimetres.		
Cent.	Fah.	Graphic curve.	Formula.	Graphic curve.	Formula.	Graphic curve.	Formula.	
						m.m.	m.m.	
—32	—25·6	0·00618	0·00616	$\bar{3}$·7915320	$\bar{3}$·7898443	0·320	0·319	—
30	22	0·00746	0·00745	$\bar{3}$·8729693	$\bar{3}$·8722283	0·386	0·385	—
25	13	0·01170	0·01179	$\bar{2}$·0681376	$\bar{2}$·0717278	0·605	0·610	+
20	4	0·01792	0·01830	$\bar{2}$.2534617	$\bar{2}$·2624643	0·927	0·946	+
15	+ 5	0·02707	0·02786	$\bar{2}$·4325100	$\bar{2}$·4449631	1·400	1·441	+
10	14	0·0405	0·0416	$\bar{2}$·6071512	$\bar{2}$·6197339	2·093	2·154	+
5	23	0·0602	0·0612	$\bar{2}$·7795611	$\bar{2}$·7872300	3·113	3·168	+
0	32	0·0889	0·0887	$\bar{2}$·9491398	$\bar{2}$·9478656	4·600	4·586	—
+ 10	50	0·1771	0·1779	$\bar{1}$·2485775	$\bar{1}$·2501297	9·165	9·199	+
20	68	0·3663	0·3383	$\bar{1}$·5266816	$\bar{1}$·5293209	17·39	17·49	+
30	86	0·6101	0·6135	$\bar{1}$·7853814	$\bar{1}$·7878696	31·55	31·73	+
40	104	1·0618	1·0664	0·0260334	0·0279153	54·91	55·15	+
50	122	1·7786	1·7830	0.2500754	0·2511622	91·98	92·21	+
60	140	2·8771	2·8797	0·4589557	0·4593577	148·79	148·92	+
70	158	4·5072	4·5067	0·6539056	0·6538550	233·09	233·06	—
80	176	6·8575	6·8534	0·8361697	0·8359048	354·64	354·42	—
90	194	10·1604	10·1532	1·0069134	1·0066047	525·45	525·08	—
100	212	14·6959	14·6884	1·1671956	1·1669739	760·00	759·62	—
110	230	20·7618	20·7879	1·3172650	1·3178109	1073·70	1075·15	+
120	248	28·7923	28·8330	1·4592767	1·4598900	1489·00	1491·10	+
130	266	39·2341	39·2626	1·5936640	1·5939794	2029·00	2030·47	+
140	284	52·4362	52.5628	1·7196318	1·7206788	2713·00	2718·29	+
150	302	69·0706	69·2705	1·8392935	1·8405486	3572·00	3582·33	+
160	320	89·8575	89·9697	1·9535547	1·9540962	4647·00	4652·69	+
170	338	115·2466	115·2882	2·0616283	2·0617852	5960·00	5962·15	+
180	356	145·8953	145·8927	2·1640412	2·1640333	7545·00	7544·86	—
190	374	182·3062	182·4842	2·2608016	2·2612254	9428·00	9437·20	+
200	392	225·4657	225·7875	2·3530806	2·3537000	11660·00	11676·64	+
210	410	276·6692	276·5535	2·4419609	2·4417790	14308·00	14302·00	—
220	428	336·2650	335·5470	2·5266816	2·5257533	17390·00	17352·87	—
230	446	401·4268	403·5310	2·6068399	2·6058768	20915·00	20868·67	—

Now, from what we know of M. Regnault as an experimenter, and consider the means at his command throughout the numerous experiments he has made at this temperature with mercury, and the different kinds of glass, whose corrections he must have known very exactly, it is next to impossible that he could have erred to the extent of 0·12 or about ⅛th of a millimetre at the freezing point. At this point, above all others, everything is in favour of correct indications, and that his best formula (H) gave so manifest an error at this point (and at lower temperatures gave still greater errors) is proved by his adopting special formulæ for different parts of the curve, and only using formula (H) for temperatures above the boiling point. In each formula above and below the freezing point M. Regnault takes 4·600 millimetres as his standard. He had therefore arranged his constants so that the pressure at this point becomes 4·586 millimetres, being only 0·014, or about $\frac{1}{70}$th of a millimetre less than that given by experiment, and he had done so because the pressure at—10° Cent. below, and + 10° Cent. above that point is greater by the formula than that by experiment, but at these points, and (with the exception of the boiling point) all other points where the indications of the thermometer are absolutely necessary, the chances of error, he considered, become increased.

In concluding, the author would have it understood that he did not say this equation was an absolute expression of the law; but being a simple formula, embracing the whole range of the "graphic curve," and coming so very near it, from the lowest to the highest temperatures, he thought the absolute expression might be questioned, and probably a step made in the right direction.

He annexed the values of the constants, and in converting pounds per square inch into millimetres, he used the logarithm 1·7136180. For inches of mercury, 0·3087835. Specific gravity of mercury at the freezing point at Paris, 13·59593.

SEYMOUR'S IMPROVEMENTS IN SCREW STEAMERS.

As the system of screw propulsion has already so far proved its superiority as, not only, entirely to take the place of every other mechanical system of propulsion, but also, to supersede sailing vessels, any improvement upon this system must be of great importance. The only objection, so far as we are aware, to this system is the peculiar formation of the stern, or, more correctly speaking, of the rudder-post and stern framing.

The original plan, in wooden vessels was to make an opening in the "dead wood" for the reception of the screw at the stern of the vessel; a bearing carrying the end of the screw shaft being fitted to the rudder-post. It was, however, soon found that the vessel "wagged its tail" to such an extent that strengthening pieces in the shape of iron knees and braces were required to save this portion of the vessel from being worked so loose as to endanger it being entirely carried away upon encountering a storm. Hence, in the old wooden screw ships we find the sterns built unusually strong to withstand this destructive action; but as a natural consequence they were so heavy that the action of the screw was to a certain extent impeded by the thickness thus necessitated.

Upon the introduction of iron for wood—which has now become universal for screw steamers it was considered that the difficulty of strengthening the stern framing was overcome, and to a large extent this was undoubtedly the case. Still, there have been but too many instances of rudders, posts and all being carried away in consequence of the inherent weakness of the peculiar description of framing necessitated by the large opening for the screws between the rudder-post and the framing of the vessel. In order to make this part of the vessel sufficiently strong it has to be forged in one piece and for its size constitutes by far the most expensive part of the ship.

It has been found in practice as most of our readers probably are aware, that the outer bearing of a screw, or the stern-post bearing, is practically not only useless but absolutely injurious, as it was almost impossible to keep it for any length of time "true" with the rest of the screw shaft bearings. It is also a well known fact that the action of the screw interferes very greatly with the action of the rudder, not only by giving a "bias" to the vessel but also communicating a most uncomfortable tremulous motion to the steering-wheel. In order to overcome this defect, it was proposed about fifteen years ago to place the screw behind the rudder-post, the screw shaft being placed slightly on one side, just

sufficient to clear the rudder-post; the rudder at that part being cut away fo as to clear the shaft when put over. We remember a vessel having this arrangement which worked tolerably well for many years; bnt the outer bearing between the rudder and the screw was a constant source of annoyance.

Fig. 1.

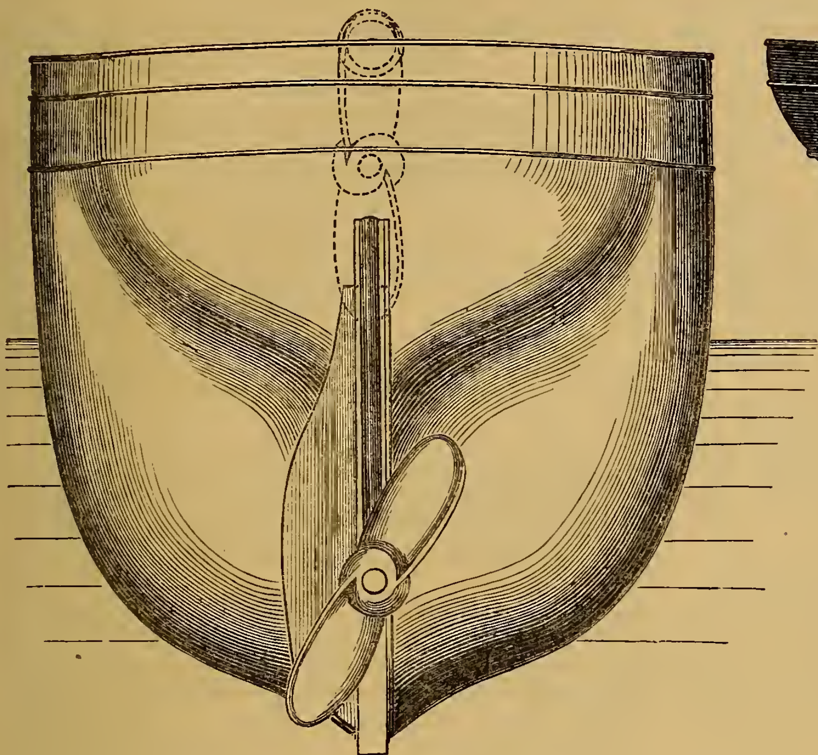


Fig. 2.

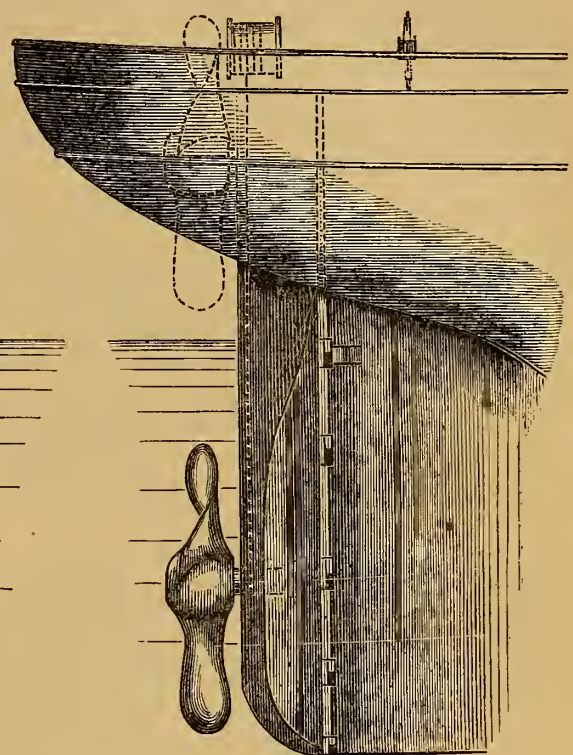
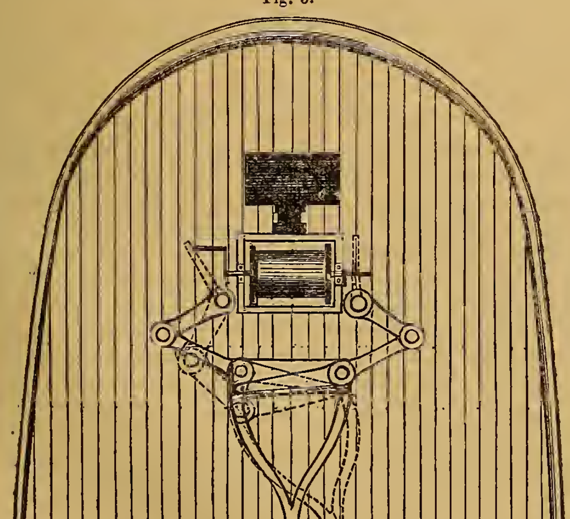


Fig. 3.



In the arrangement at present nnder notice, and which is illnstrated in the accompanying engraving, Mr. Seymour, of 54, Lime-street, has endeavoured, and we believe successfully, to overcome these objections. In order to do this he proposes to have a double stern-post bnt without any side opening to carry the propeller, which, as will be seen in the accompanying engraving is entirely ontside the vessel. For the purpose of steering the vessel Mr. Seymour has designed a very ingenious combination of two rudders, or, rather, two half-rudders, fitted one on each side of the stern-post. The screw is provided with a firm bearing between the two stern-posts which are placed only a sufficient distance apart to allow the stern-shaft to slide up and down, by which means the screw, when not in action, may be drawn up out of the water by the windlass shown on the deck or lowered into its working position, as represented in the engraving in dotted lines, with the greatest facility.

The rudders are hung in pintles in the usual manner, one on each side of the stern-post, and by a very ingenious arrangement are worked by a single wheel. This plan is shown in Fig. 3, where the full lines show the wheel in the centre, and both rudders quiescent. When, however, the rudder is pulled over to port, as shown in the dotted lines, the port rudder answers its helm, but the starboard rudder remains stationary. In like manner when the starboard rudder is pnlled over, the port rudder remains stationary. If it be preferred, two steering wheels may be used, one to each rudder in the usual manner, and as there are generally two men at the wheel when only a single rudder is used no extra men would be required.

The advantages of this system, so far as regards strength, are so obvious that they need scarcely be pointed ont. It is well known that it is not an unusual thing for a screw steamer to lose its rndder, or at least to have it disabled. In the position in which the rudders are placed in the plan under consideration such an accident could be scarcely possible. Another disadvantage in the common system of placing the screw before the rudder is, that, to a certain extent, the sorew works in a partial vacuum formed by the rapid passage of the ship through the water. Again, a certain portion of the water driveu aft by the screw strikes against the rudder-post, and also against the rndder when pnt over; bnt in Mr. Seymour's plan, it is obvious that no such action can occur. As far as we can jndge, this arrangement appears to be a decided improvement over the usual plan, and we shall be glad to hear of its being tried upon a large scale.

NOTES AND NOVELTIES.

MISCELLANEOUS.

The report of the select committee appointed to inquire into the working of the Patent Law has been issued. The report recommends that the committee be reappointed at the commencement of next session to continue their inquiry. The committee desire to state, without prejudging any question referred to them, that in the meantime it is highly desirable that the powers and provisions of the Patent Law Amendment Act, 1852, should be fully carried into effect. The evidence reported is that tendered before the committee by Mr. W. R. Grove, Q.C., Mr. Thomas Webster, Q.C., Sir Roundell Palmer, Mr. Theo. Aston, Mr. Peter Robert Hall Henson, M. Eugene Schneider, Mr. Henry Bessemer, Mr. Isaac Holden, Mr. Lucius Eugene Chittenden, Mr. James Nasmyth, Sir William Armstrong, Mr. William Marwick Michell, and Mr. R. A. Macfie, M.P.

The North Staffordshire ironmasters, at a meeting held on the 15th ult., decided to advance puddlers' wages a shilling a ton, and those of millmen 10 per cent., with a proportionate increase on finished iron. It is anticipated that this concession will meet the demands of the men, and avert the threatened strike.

Various experiments have been made in the public establishments at Chatham, the dockyard, the wharf, &c., with a new patent "spray nozzle," for the rapid extinction of fires, the inventor being Mr. Prosser, of Manchester. The nozzle is so constructed that it can be made to discharge a single stream the same as the ordinary apparatus; but by the turning of a small screw some ten valves are brought into use, and by this means the water is thrown out in a dense mist. Capt. Chamberlain, Superintendent of Chatham Dockyard, accompanied by various officials, has just witnessed some experiments which were made under the direction of Mr. J. Strength, Superintendent of Police and Chief of the Dockyard Fire Brigade, the nozzle being attached to the steam fire engine. The whole of the experiments at Chatham have been most satisfactory.

An American idea of training up a Child in the way he should go &c.—An ingenious toy for children is a small steamer which explodes by machinery, scattering the passengers in every direction.

There have been very alarming floods in the Punjab and in Guzerat. Railway bridges over the Jumna, beyond Saharunpore and over the Beas beyond Jullundur have become impassable, and passenger and goods traffic has been stopped between Saharun pore and the Beas river. The valuable bridge across the Beas was, indeed, broken down and a train was precipitated into the gulf beneath. About 180 yards of the Punjab Railway on the Jullundur side of the river was also carried away by the flood. Happily there does not appear to have been any lives lost by the falling of the doomed train into the Beas; when the disaster happened almost every one had left the carriages.

NAVAL ENGINEERING.

The *Bromberger Zeitung*, in a letter from Dantsic, gives some particulars regarding a curious and interesting addition to the German fleet. Three boats are just in course of construction in Devrient's dockyard, the destination of which is to place torpedoes under, and thus, destroy, an enemy's ships. These boats are built almost entirely of iron, and, being about 60ft. long and only six or seven broad, they have nearly the form of a fish. The deck is not flat, but round, so as to be but little exposed to danger from an enemy's shot. While employed in active operations no one will be visible on board. Contrary to the usual system, these boats will be steered from the bows; and on the deck, above the rudder, there is a slight elevation to allow the steersman to stand on his feet, and a small opening about an inch wide to serve him as a look-out. As they are intended to operate close to an enemy's vessels the armour will be as thick as is consistent with high speed. the most curious part of the invention, perhaps, is that the tiny screw steamers, or Barcassen (long boats), as they are called, use petroleum as fuel, which is contained in a number of iron receptacles in the stern, of sufficient thickness to be impervious to projectiles. The chimney is so small that it can scarcely in any case be hit. A narrow gallery, about a foot broad, and enclosed by an iron chain, runs round the boat. The machines have all been furnished by Stöckel and Wagenknect, so that the boats have been produced in Dantsic from stem to stern. The hold for the Torpedoes is in the middle of the boat, as well as the quarters of the crew. One of the Barcassen has already been launched, and is only waiting for her engine. The two others are still on the stocks. A liliputian steamer has also been constructed in the same dockyard, in which the inspector of the harbour-works will be able to go on his rounds with great rapidity. The whole thing is not larger than an average-sized rowing-boat; it has no deck, and in the middle is the miniature steam-machine, which is no more than two feet in diameter, and requires but little attention.

MILITARY ENGINEERING.

The 35-ton gun commonly known as the "Woolwich Infant" has had its bore enlarged at the Royal Gun Factories of the Royal Arsenal from 11·6in. to 12in., and was on the 1st ult. conveyed to the proof butts in Plumstead marshes for further trial. Twelve inches was the calibre contemplated in the original design of the gun, but being the first of its kind, and therefore in some degree experimental, it was determined in the first instance to try the small bore, with which, as already reported, a 700lb. shot was fired with varying charges, up to 130lb., of pebble powder. It was found, however, that the diameter of 11·6in. did not allow sufficient capacity for consuming more than about 115lb. of powder, the remainder being blown out of the muzzle unburnt, and the full consumption being requisite to insure the desired velocity and consequent range and penetration, the Government has adopted the recommendation of the Select Committee, and enlarged the bore, leaving still, it is believed, a sufficient thickness of metal in the gun to endure the heavier strain to which it will now be subjected. The new trials cannot however be made just yet, as the enlargement of the gun will necessitate larges projectiles, and these have yet to be made.

STEAMSHIPPING.

We (*Dundee Advertiser*) have pleasure in stating that a new steam shipping company has been formed on a broad basis and with a large capital for the purpose of running steamers by the Suez Canal to Calcutta. With the view of securing outward cargoes, an influential class of large exporting firms in Liverpool, Manchester, and Glasgow have become shareholders, while they, knowing the importance of the jute trade, have wished the spinners and jute importers in Dundee to take an interest in the company, so that the vessels in the jute season might obtain freights to this port. The company has accordingly been joined by some of our principal spinners and importers of jute—most of whom have taken from £2,000 to £5,000 of stock in the concern—upwards of £50,000 having been taken altogether—and who have chosen one of their number to be a director of the company, who will at once enter on his duties, attend its meetings, and superintend its interests in this quarter. There are already four steam vessels building for the company on the Clyde, each capable of carrying 2,600 tons, and of ample engine power. They are being built of the first class as regards strength—having plain substantial equipments —while they will be specially fitted and thoroughly ventilated for carrying jute cargoes— each being capable of storing the large quantity of 15,000 bales. The first vessel of this line is expected to be ready in November. The vessels will be managed by Messrs. Stoddart Brothers, Liverpool, and will go to Messrs. Finlay, Muir, and Co., at Calcutta. The outward cargoes will be shipped principally at Liverpool, but also as occasion offers at London and Glasgow. As the trade is developed, the number of steamers will be increased.

The iron-clad frigate *Normandie*, built at Cherbourg, and which had inaugurated the transformation of the French fleet, has just been ordered to be broken up at Toulon, where it has been disarmed. This vessel, which has cost millions, has only lasted ten years. Its framework, attacked by dry rot, scarcely held together. It had to be condemned as unfit for service, and when it is being demolished it will probably fall to pieces. The plating will be thrown aside as old iron, and the engines will be sent to the store-house until they can be utilised.

The Russian Steam Navigation Company's steamer *Thighatcheff*, has returned from Shanghai, after a continued outward and home voyage through the Suez Canal of a little more than five months. She brings a cargo of 66,000lb. of tea; of the value of 1,000,000 roubles.

SHIPBUILDING.

There are now under construction for her Majesty's Government, at the various public and private dockyards, twenty-one ships, which may be classified as under; 1 iron screw frigate, cased with wood; two turret ships armour plated; 3 double-screw iron armour-plate turret ships; 1 iron screw frigate, sheathed with wood; 1 ironclad ram, 3 screw corvettes, 1 screw frigate. 5 composite gunboats, and 4 double-screw composite gun vessels. The following are the names of the ships, together with the number of guns, tonnage, and place of building; *Amethyst*, 14, 1,405 tons, Devonport; *Blonde*, 26, 4,039, Portsmouth; *Decoy*, 4, 295, Pembroke; *Encounter*, 14, 1,405, Sheerness; *Frolic*, 4, 462, Chatham; *Fury*, 4, 5,030, Pembroke; *Gorgon*, 4, 2,107, Jarrow-on-Tyne; *Goshawk*, 4, 295, Pembroke; *Hecate*, 4, 2,107 Poplar; *Hydra*, 4, 2,107, Glasgow; *Kestrel*, 4, 462, Chatham; *Merlin*, 4, 295, Pembroke; *Modeste*, 14, 1,405, Devonport; *Mosquito*, 4, 295, Pembroke, *Raleigh*, 22, 3,210, Chatham; *Ready*, 4, 462, Chatham; *Rifleman*, 4, 462, Chatham; *Rupert*, 4, 3,159, Chatham; *Swinger*, 4, 295, Pembroke; *Thetis*, 13, 1,322, Devonport; *Thunderer*, 4, 4,407, Pembroke.

LAUNCHES.

On the 14th ult. there was launched from the Clydeholm Works of Messrs. Barclay, Curle and Co., an iron sailing ship, of about 1,700 tons register, for Messrs. J. and A. Allan. She was named the *Strathearn*, by Miss Curle, Crown Circus.

On the 18th ult. Arch. M'Millan and Son, Dumbarton, launched from their dockyard a very handsome screw steamship of 2,500 tons, of dimensions 340 by 38 by 27½, which was named *Memphis* by Miss Weeks, of New Orleans, daughter of Captain Silas Weeks, who goes in command of the vessel. The *Memphis* is built to the highest class at Lloyd's, and is being fitted up in a very first-class style, for the Liverpool and Mississippi Steamship Company's New Orleans trade, to whose order she has been built. The same builders have in course of construction other two vessels of nearly similar dimensions for the same owners, one of which will be launched in about six weeks hence. Messrs. John and James Thomson, Glasgow, are supplying the *Memphis* with a powerful pair of compound engines.

On the 19th ult. there was launched from the shipbuilding yard of Messrs. Tod and Macgregor, Partick, a magnificent vessel named the *City of Montreal*, belonging to the Liverpool, New York, and Philadelphia Steamship Company. The ship was gracefully named the *City of Montreal* by Mrs David Tod. The dimensions of the vessel are as follow:—Length from taffrail to back of figure, 433ft.; beam, moulded, 43ft. depth, moulded, 36ft.; tonnage, B.M., 3,800 tons; tonnage, gross register, 4,600 tons. The *City of Montreal* is built with a clipper bow, is ship rigged, and is spar decked, with plate-iron bulwarks. The promenade deck is fitted with steam windlass, cargo winches, and other appliances for managing the ship and handling her cargo. Amidships there are the captain's cooking galleys, and male and female hospitals; and there is an elegant smoking room aft for saloon passengers. Along the sides and on the same deck are arranged ten lifeboats, water-closets and lavatories for emigrants, workshops and stores for ship. The extreme forward portion of spar or second deck is fitted with ice-houses, sail-rooms, &c.; and abaft is fitted up for 400 third-class passengers. Amidship is the accommodation required for firemen and crew. Abaft that come the officers' and engineers' rooms; still further aft are state-rooms, for about 140 first-class passengers, and in the stern is the dining saloon for their accommodation. Large-sized state-rooms are set apart for ladies' and gentlemen's cabins and for the captain. The entire main or third deck fitted up specially for the emigrant service, affording sleeping berths for about 1,100 passengers in addition to those on spar deck. The ship is divided off into ten water-tight compartments, and has all the mail and specie-rooms necessary for the post office service. The engines for this vessel, of 600 H.P. nominal, have been constructed by the builders at their Clyde Foundry and will be put on board at the large crane at Finnieston Quay.

TRIAL TRIPS.

The new s.s. *Ardeer*, owned by Messrs. Merry and Cunninghame, ironmasters, Glasgow, and built by Messrs. John Fullerton and Co., shipbuilders, Merksworth, Paisley, proceeded down the river on the 5th ult. on her official trial trip. After adjusting compasses at the Gareloch she steamed several runs at the measured mile, her average speed being about 10 knots. Her principal dimensions are:—Length, 147ft. 6in.; breadth, 22ft.; depth of hold, 11ft. 6in.; deadweight capacity, 370 tons; built to the highest class at Lloyd's. She is fitted with water ballast tanks, has two steam winches, and all the latest improvements. Her engines, which were supplied by the well-known firm of Messrs. William King and Co., Dock Engine Works, Glasgow, are on the compound principle, 56 H.P. nominal; high-pressure cylinder 21in. diameter, low-pressure cylinder 35in. diameter, and both 24in. stroke. They are supplied with steam by a horizontal tubular boiler, 9ft. long and 11ft. 6in. diameter, which give abundance of steam at 60 lbs. pressure. The engines worked during the trip in the most satisfactory manner. The *Ardeer* proceeded to Bowling, where she is to load pig iron for an English port.

The North German Lloyd screw steamship *America*, Captain R. Bussius, which has undergone a complete overhaul and refit at the iron shipbuilding yard of Messrs. Day, Summers, and Co., at this port, went out on the 13th ult. for a trial of her new machinery, the result of which was in every way satisfactory, her mean speed being found to be 12½ knots per hour, with 55lb. steam pressure. The *America* has been fitted with new high-pressure boilers, tested to 130lb. per square inch, and new compound cylinders have also been applied to her old engines. The diameter of each of the old cylinders was 72in. and 4ft. stroke; that of the new high-pressure cylinder is 62½in., and the low-pressure ditto 96in., of course having the same stroke as the old pistons. The object of these alterations is to economize the fuel consumed, and, from the results obtained by the trial, a saving of 25 per cent. is confidently anticipated, the speed of the vessel being at the same time fully preserved.

RAILWAYS.

A concession has been obtained for a short underground railway between Galata and Pera to be worked on the pneumatic system. The promoters intend to commence the tunnel at once; there will be two or three intermediate shafts for light and air. The Galata station will be in the Rue Voivoda, and the outlet at Pera will be in the Rue Kibristan near the municipal buildings. The transit will be effected in two or three minutes, and at very frequent intervals during the day.

A general rise of railway fares in Belgium is to take effect on the 1st of November.

The new railway connecting Blackheath and Greenwich with the station at Ludgate-hill, which has just been constructed by the Chatham and Dover Company, was opened for traffic on the 18th ult. The new line, which is three miles in length, commences by a junction with the Crystal Palace High Level line of the company at Nunhead, and, passing through Lewisham and Brockley, has its present terminus at Blackheath Hill, the ultimate intention of the company being to carry the line forward to a further distance of four miles, where it will form a junction with the North Kent line and the South-Eastern system at Charlton. In addition to the Nunhead and Blackheath Hill stations, there are two intermediate stations at Lewisham and Brockley.

The Melbourne and Hobson's Bay Railway was laid in the first instance with rails weighing 55lb. per yard. The weight of the engines used upon the line was under 25 tons, but the rails failed in less than three years. The line was relaid about 14 years since with rails weighing 75lb. per yard, and these were in good order a since. The St. Kilda branch of the Melbourne and Hobson's Bay Railway was laid in the first instance with rails weighing 55lb. to the yard, and placed in longitudinal sleepers; in less than two years these rails had to be taken up, and the line was relaid with rails weighing 75lb. and 80lb. a yard. These were a year since in good condition.

TRAMWAYS.

The tramway lines between Blackfriars Bridge, East Greenwich, and Blackheath-hill were opened throughout on the 6th ult. The first car left East Greenwich at eight, and the cars will continue to leave every ten minutes throughout the day until 10.10. p.m. On Sundays the cars will commence running at 9 a.m. and continue until 9.40 p.m. From Blackheath-hill the first car left in the morning at eight minutes past eight, and the cars will continue to start every twenty minutes until 12 p.m. Passengers from Blackheath-hill change cars at Deptford Bridge Junction. The first car left Blackfriars Bridge at 9.4. a.m., and the cars will continue to run to Greenwich and Blackheath every ten minutes throughout the day until 11.14 p.m. On Sundays the cars will commence running from Blackfriars at 10 a.m., and run every ten minutes until 10.44 p.m. The journey to Blackheath is performed in about forty minutes.

ACCIDENTS.

A very serious accident occurred on the Wansbeck Valley Railway at Morpeth on the 15th ult. The half-past 1 p.m. train from Newcastle and Morpeth to Scots' Gap and Rothbury had left the station, and had reached the summit of an incline, when the coupling chain of a carriage broke, and three carriages and a van suddenly ran down upon the engine of a goods train which was about to follow the passenger train up the Wansbeck Valley. Among those injured were Dr. Heath, Newcastle physician and surgeon, who was much cut about the face and otherwise injured; Dr. Brumell, of Morpeth, Mr. Dunn, a South Shields tradesman, and three women belonging to the west of Northumberland, one of whom, Isabella Swanson, is severely injured about the head, and was taken from the carriage unconscious.

On the 15th ult. a somewhat disastrous collision occurred on the Hartlepool and Ferryhill branch of the North-Eastern Railway, which caused a complete block for nearly five hours. It appears that a long coal train, destined for shipment at Hartlepool, was standing at the Trindon station, where it had been taking in water, when a second coal train, which was following upon the same line, came up at a rapid speed, and by some mischance, the signals not having been placed against it, dashed into the standing train, smashing the break van and throwing several of the coal waggons off the rails. Fortunately, the guard was not in his van at the moment of the accident, therefore he escaped injury, and the driver and fireman of the coal train, by whose endeavours to avoid a collision the speed of the latter had been considerably reduced, escaped by jumping off, with a shaking; although the driver, Baister, fell, and was nearly run over. The effect of the accident was to dislodge some of the rails, and from the *debris* of the waggons and their contents a complete block was occasioned on both lines until nearly 11 o'clock; consequently the train due at Trindon at 9 50 from Ferryhill, and at Hartlepool at 10 25 p.m. was delayed until past 11 o'clock. It was not until some three hours that the breakdown gang from Hartlepool, under Mr. Thomas James, were enabled to restore the two lines to their proper condition.

DOCKS, HARBOURS, BRIDGES.

A company has been formed and has obtained power to erect a pier at Coatham, the adjoining watering place to Redcar.

A large graving dock, just constructed at Port Chalmers, New Zealand, was recently opened for use, with appropriate ceremonies. Port Chalmers has been fixed upon as the port to be connected with San Francisco by the new line of steamers between New Zealand and California. Railroads are also in course of construction from Port Chalmers to other important places on the island.

The Leith Dock and Harbour Commissioners are about to erect an iron swing bridge at Leith Harbour, to span 120ft. of waterway, and hydraulic machinery and apparatus for working the bridge.

A Ship Canal connecting Lake Huron and the St. Clair river with the Detroit river, has been formally accepted by the United States, the work being declared to have been executed according to contract. The canal was commenced in the spring of 1868, and has cost about 428,000 dols. The work consists of two long dykes, each 7221ft. long, 40ft. wide, and constructed of sand and clay enclosed in frames of timber. At each end of the west dyke, which is towards the Michigan shore, are buildings in course of construction as lighthouses; the one at the southern end is nearly completed, and the foundations only of the other have been finished. The canal itself, embracing the distance it has been dredged out, is 8421ft. long, including 7221ft. of dykes and two bays, the upper one 400ft., and the lower one 800ft. long. The width of the canal at the bottom at the entrance of the bays is 416ft., and it is 300ft. between the two dykes.

APPLIED CHEMISTRY.

Some very interesting observations have been made on the properties of gun cotton. This substance, obtained with the ordinary process used by the manufacturers of collodion, is not soluble in alcohol; but, with the addition of a little camphor, it dissolves instantaneously. A beautiful artificial ivory is prepared by powdering gun cotton with camphor, and placing it under hydraulic pressure, covering it afterwards with a mixture of gun cotton and castor oil; by this process billiard balls have been produced, which have been declared by connoisseurs to be superior to those of real ivory.

A new apparatus for gas making has just been introduced by M. Rouille in Paris, by which gas can be produced economically, and with the simplest apparatus, in houses, manufactories, etc. The inventor has named this gas "Gas Autogène." It is formed of air and steam of essence of petroleum. The apparatus for the supply of 1,000 burners does not occupy more than a square yard, and for a less number, in proportion. The gas is said to give a much more brilliant light than ordinary gas, and to be much cheaper. In fact, it is stated that half a cubic yard of "gas autogène" gives as much light as a cubic yard of ordinary gas, and that it costs only three cents per cubic yard. An apparatus, with reservoir complete for fifty burners, is manufactured at the price of £24, and one ditto for 100 burners, for £40.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	78	0	0	,,	,,	,,
Tough cake and tile do.	76	0	0	77	0	0
Sheathing and sheets do.	77	0	0	80	0	0
Bolts do.	79	0	0	80	0	0
Bottoms do.	81	0	0	83	0	0
Old do.	60	0	0	,,	,,	,,
Burra Burra do.	77	0	0	,,	,,	,,
Wire, per lb.	0	0	9⅞	0	0	10
Tubes do.	0	0	10½	0	0	10¾
BRASS.						
Sheets, per lb.	0	0	8	0	0	8¾
Wire do.	0	0	8	,,	,,	,,
Tubes do.	0	0	8	0	0	10½
Yellow metal sheathing do.	0	0	6¾	0	0	7½
Sheets do.	0	0	6⅝	0	0	7
SPELTER.						
Foreign on the spot, per ton.	18	5	0	18	10	0
Do. to arrive.	18	5	0	,,	,,	,,
ZINC.						
In sheets, per ton	24	10	0	,,	,,	,,
TIN.						
English blocks, per ton.	136	0	0	137	0	0
Do. bars (in barrels) do.	137	0	0	138	0	0
Do. refined do.	140	0	0	,,	,,	,,
Banca do.	135	0	0	136	0	0
Straits do.	131	0	0	132	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	9	6	1	10	6
IX. do. 1st quality do.	1	16	0	1	17	6
IC. do. 2nd quality do.	1	7	6	1	8	0
IX. do. 2nd quality do.	1	13	6	1	14	0
IC. Coke do.	1	5	0	1	7	0
IX. do. do.	1	11	0	1	13	0
Canada plates, per ton	13	10	0	15	0	0
Do. at works do.	13	10	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	8	0	0	8	10	0
Do. to arrive do.	7	17	6	8	0	0
N]rods do.	8	0	0	,,	,,	,,
Do. Stafford in London do.	8	15	0	9	0	0
Bars do. do.	8	15	0	9	2	6
Hoops do. do.	9	12	6	10	0	0
Bars do. at works do.	8	0	0	,,	,,	,,
Hoops do. do.	8	15	0	,,	,,	,,
Sheets, single, do.	10	10	0	,,	,,	,,
Pig No. 1 in Wales do.	4	10	0	5	10	0
Refined metal do.	4	10	0	5	10	0
Bars, common, do.	7	0	0	7	2	6
Do. mrch. Tyne or Tees do.	7	15	0	8	0	0
Do. railway, in Wales, do.	7	0	0	7	15	0
Do. Swedish in London do.	10	5	0	10	10	0
To arrive do.	10	0	0	10	5	0
Pig No. 1 in Clyde do.	3	3	0	3	10	0
Do. f.o.b. Tyne or Tees do.	2	9	6	,,	,,	,,
Do. Nos. 3 and 4 f.o.b. do.	2	6	6	2	7	0
Railway chairs do.	5	17	0	6	0	0
Do. spikes do.	11	0	0	12	0	0
Indian charcoal pigs in London do.	6	5	0	6	10	0
STEEL.						
Swedish in kegs (rolled), per ton	12	5	0	13	0	0
Do. (hammered) do.	13	0	0	14	0	0
Do. in faggots do.	15	0	0	16	0	0
English spring do.	17	0	0	23	0	0
Quicksilver, per bottle	10	15	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	0	0	,,	,,	,,
Ditto L.B. do.	18	2	6	18	5	0
Do. W.B. do.	,,	,,	,	,,	,,	,,
Do. sheet, do.	18	10	0	,,	,,	,,
Do. red lead do.	20	10	0	,,	,,	,,
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	20	5	0	,,	,,	,,
Spanish do.	17	10	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated August 9th, 1871.

2099 W. Avery—Needle cases

Dated August 10th, 1871.

2100 W. Whieldon W. B. Hays, and J. J. Hays—Preparation of peat
2101 C. P. Matthews—Brewing beer
2102 J. Upton—Shoes for horses
2103 E. Jones and A. Gray — Working pumps, &c.
2104 F. W. Gilbert—Regulating frames
2105 A. B. and D. M. Childs — Dressing millstones
2106 W. R. Lake—Covering wire
2107 A. V. Newton—Windmills
2108 G. Knowles, jun.—Combing cotton
2109 J. Beckett and J. J. Cam — Treating sewage
2110 G. Zeller—Firearms
2111 T. C. Pearson—Seed planter
2112 T. C. Pearson—Filters
2113 T. C. Pearson—Tilt for casks
2114 G. H. Goodman—Breaking stone
2115 T. C. Pearson—Lubricator
2116 T. Hyatt—Illuminating gratings
2117 J. Pollock—Chairs, &c.
2118 T. Hyatt—Inkstands
2119 T. Hyatt—Sheet metal

Dated August 11th, 1871.

2120 A. A. Cochrane—Breakwaters
2121 W. Winter—Sewing machines
2122 J. Young—Soda
2123 J. Young—Treatment of oils
2124 C. G. Harston—Firearms
2125 J. T. Smith—Umbrellas
2126 J. T. Smith—Holding umbrellas
2127 A. Pilbeam—Sewing machine

Dated August 12th, 1871.

2128 H. Zahn—Screw propellers
2129 R. Gannt—Hinges
2130 A. C. Andrews—Sewn boots
2131 J. Macpherson—Steamships, &c.

Dated August 14th, 1871.

2132 R. Nicholls—Fringes, &c.
2133 J. Newby—Boots
2134 J. Anderson—Reducing oxides
2135 T. Roberts—Filtering liquids
2136 J. Sibert—Dressing lace
2137 T. Giles—Steam engines
2138 W. R. Lake—Dress protectors

Dated August 15th, 1871.

2139 A. Balme and A. B. Crossley—Punching plates
2140 J. I. Lupton—Deodorising sewage
2141 C. Finlayson—Tension pulleys
2142 F. J. Chatfield—Furnaces
2143 J. A. Smart—Extracting grease
2144 B. Hunt—Tanning hides
2145 W. Mitchell—Printing felt carpets
2146 W. E. Newton—Preparing grain
2147 J. J. Jenkins—Tin plates
2148 J. H. and C. White—Attaching buttons to boots
2149 Sir J. Whitworth—Ordnance
2150 W. R. Lake—Signal apparatus
2151 W. R. Lake—Bale tie
2152 W. R. Lake—Cylinders
2153 D. C. Lowber—Presses, &c.

Dated August 16th, 1871.

2154 M. Curtis and W. H. Rhodes—Preparing cotton, &c.
2155 M. Richardson—Pressing bricks
2156 J. W. Beasley—Ball valve
2157 T. J. Smith—Lighting gas
2158 C. Douglas and D. M. Watson — Treating stone, &c.
2159 R. Nicholls—Ribbons, &c.
2160 J. Belicard—Looms
2161 A. M. Clark—Labelling boxes
2162 A. M. Clark—Auxiliary springs
2163 F. Macken—Spinning

Dated August 17th, 1871.

2164 W. Holt—Hydraulic engine
2165 J. D. Larsen—Brakes for carriages
2166 G. Haseltine—Plates for sun pictures
2167 J. Blick and W. Bishop—Removing dust from carpets
2168 J. H. Johnson—Treatment of animal fibres, &c.

Dated August 18th, 1871.

2169 W. Weldon—Recovery of sulphur, &c.
2170 W. Weldon—Chlorine
2171 W. E. Gedge—Signalling
2172 C. Wheatstone and J. M. A. Stroh—Telegraph apparatus
2173 J. Norman—Abstracting heat
2174 J. H. Johnson—Looms
2175 E. Oatley—Presses, &c.
2176 D. Pratt—Thimbles
2177 K. Murray—Fences
2178 J. Hodges—Cooking ranges
2179 J. Amos—Ventilating ranges

Dated August 19th, 1871.

2180 E. J. Grabham—Regulating gas
2181 E. Jones—Cotton gins
2182 J. Hosking—Rendering spanners adjustable
2183 L. Stenger—Flattening glass
2184 S. Holmes—Optical instruments
2185 T. Sturgeon—Dressing millstones
2186 W. Williams—Laystalls
2187 T. Westlake and H. Thompson — Cleaning flax
2188 S. H. Emmeus—Artificial rock
2189 W. H. Moore—Filters
2190 G. Whight—Hand clamps
2191 W. R. Lake—Breaking stone

Dated August 21st, 1871.

2192 J. Williamson, E. Williamson, and J. C. Shield—Looms, &c.
2193 A. Morrall—Improved needle
2194 J. R. Breach—Gas fires
2195 J. J. Monteiro—Treatment of fibrous substances
2196 A. B. Fleming, R. C. Maglagan, and R. Irvine—Lubricants, &c.
2197 S. C. Lister—Looms
2198 J. Adams—Steam boilers
2199 A. M. Clark—Smoothing irons

Dated August 22nd, 1871.

2200 R. C. Moffatt and A. McLaren — Treating oils
2201 G. M. Wilson—Doubling frames
2202 J. Paterson—Manufacture of sugar
2203 W. E. Gedge—Ball-proof plastron-cuirasse
2204 J. Salter—Trusses
2205 St. J. V. Day—Wheels of engines
2206 J. Phillips—Box-iron
2207 N. Jochumsen—Valves
2208 J. H. Johnson—Volocipedes
2209 A. P. Price and R. Irvine—Paper
2210 W. E. Newton—Skylights
2211 A. V. Newton—Spreading flax
2212 H. Codd—Bottles

Dated August 23rd, 1871.

2213 J. T. Hayes and W. Deakin—Pipes for smoking tobacco
2214 W. R. Lake—Looms
2215 J. Shore—Tapping casks
2216 J. Anderson—Furnaces, &c.
2217 J. Hildesheim—Obtaining fresh water from salt water
2218 J. H. Johnson—Apparatus for heating
2219 W. R. Lake—Galvanic battery

Dated August 24th, 1871.

2220 J. Barr—Propulsion of ships
2221 J. U. Borland—Preparing fibrous materials
2222 A. M. Clark—Composition
2223 G. Watson and H. Andrews — Safety valves
2224 H. Greaves—Permanent ways
2225 L. Pasteur—Brewing
2226 W. R. Lake—Tiles

Dated August 25th, 1871.

2227 W. A. Alcorn—Protection of bottles
2228 F. A. Paget and J. W. Asher—Abstracting heat
2229 C. D. Abel—Steam engines
2230 W. Cross—Cutting faces of sad irons
2231 T. J. Smith—Producing ammonia
2232 T. J. Smith—Chlorine
2233 F. Parry—Drying sewage
2234 J. J. Campbell—Packing tubes
2235 Major E. R. Wethered—Hammocks
2236 F. Mignot—Sewing saddlery
2237 J. T. Dann—Pearl hardening
2238 W. R. Lake—Motor machine
2239 C. McKinney Talbot—Strengthening button holes
2240 W. R. Lake—Bed or couch

Dated August 26th, 1871.

2241 P. O'Connor—Hinges
2242 P. H. Astley—Life boats
2243 H. Y. D. Scott—Treatment of sewage
2244 G. C. Wilson—Transforming guns
2245 J. Amos—Improvements in ventilation
2246 G. F. Muntz—Gaffs for ships
2247 K. W. Zenger—Gas
2248 W. H. Chase—Lever apparatus
2249 W. Prosser—Pulverising substances

Dated August 28th, 1871.

2250 J. H. Webber—Chimney flues
2251 R. Gaunt—Parts of nails, &c.
2252 C. T. Burton—Pulp for paper
2253 A. B. Brown—Slide valves
2254 G. Haseltine—Utilising the explosive force of gas
2255 P. N. Priqueler—Punching pins
2256 C. Davis and T. Struthers — Boot soling, &c.
2257 H. Hirsch—Screw propellers
2258 C. D. Abel—Furnace grates
2259 C. D. Abel—Dyeing woollen waste
2260 L. L. A. E. P. de la Peyrouse—Treatment of fatty matters
2261 J. H. Johnson—Generation of steam
2262 W. B. Robinson—Cylinders, &c.
2263 W. Webb—Joints of metal pipes

Dated August 29th, 1871.

2264 J. Burton and J. Mellers — Clipping sprigged nets
2265 H. Southwell—Bobbins
2266 T. Feam—Depositing alloys
2267 J. Townsend—Treating phosphates
2268 J. Edge—Boilers
2269 E. P. H. Vaughan—Stannate of soda
2270 R. Saunders—Ships, &c.
2271 W. E. Newton—Reducing rags, &c.
2272 E. A. Slater and G. W. Schollar—Umbrellas
2273 J. Wright—Constructing tunnels

Dated August 30th, 1871.

2274 H. Bright—Drying sewage
2275 J. House—Extracting weeds
2276 H. Davis—Sash frames
2277 J. C. Ramsden—Looms
2278 T. J. Thompson—Permanent way of railways
2279 E. H. and G. Hatton—Working Venetian blinds
2280 A. M. Clark—Signal apparatus
2281 A. Guattari—Gloves
2282 H. A. Johnson—Compound solution
2283 I. M. Milbank—Firearms
2284 W. R. Lake—Spinning wool
2285 A. S. Campbell—Changing the flow of steam, &c.
2286 G. Little—Telegraph apparatus
2287 W. E. Newton—Billiard markers
2288 G. Haseltine—Matches

Dated August 31st, 1871.

2289 E. Bazin—Extracting slime, &c.
2290 J. Leadbetter—Brewing, &c.
2291 W. Ashcroft—Cardboard
2292 C. D. Abel—Dyeing wool
2293 F. Ransome—Millstones
2294 W. Stanf—Substitute for horsehair
2295 J. T. Cocking—Plastic material
2296 A. H. Brandon—Projectiles
2297 G. C. Bell—Forging bolts
2298 W. R. Lake—Compound for hides
2299 G. Haseltine—Mills
2300 J. H. Johnson—Printing machines

Dated September 1st, 1871.

2301 H. Hughes—Unscrewing bolt nuts
2302 T. H. Tayler—Sowing seed
2303 A. Welch—Cattle trucks
2304 G. L. Behrns—Application of exhaust to millstones
2305 R. J. Bulkeley—Loading trucks
2306 E. Thornton—Kitchen ranges
2307 J. Dodgeon and B. Baldwin—Looms
2308 J. N. Leather—Bleaching powder
2309 C. Hoyle—Washing wool

Dated September 2nd, 1871.

2310 E. Burstow—Sash fastener
2311 A. Ford—Linseed oils
2312 G. Fouud, H. Watson, and J. Erck Obtaining motive power
2313 Sir W. Fothergill-Cooke—Construction of railways
2314 A. H. Bateman—Artificial fuel
2315 A. Briart—Screening coal
2316 R. Warry—Cooking apparatus
2317 C. J. L. Leffler—Furnaces
2318 M. Hesse—Copying letters
2319 J. and T. Priestman—Rolling leather
2320 W. J. Cunningham—Cutting type
2321 D. Curtis—Harness
2322 M. and J. Pollock—Chairs, &c.
2323 F. Tinker, W., W. H., and G. A. Marsden—Self-supporting trousers
2324 F. Coles—Cooling mixture
2325 J. Zengeler—Colouring marble

Dated September 4th, 1871.

2326 J. Anderson—Producing currents
2327 H. Baldwin—Fluid for the prevention of incrustation in boilers
2328 M. and J. Pollock—Chairs, &c.
2329 J. Hargreaves and T. Robinson — Chlorine
2330 L. Helliwell — Extracting animal fibres, &c.
2331 A. M. Clark—Saws
2332 B. Leslie—Transporting carriages
2333 C. D. and C. S. Deuempont—Shaping wood
2334 T. Carr—Manufacture of flour
2335 L. Kleritj—New cartridge

Dated September 5th, 1871.

2336 R. Vaguolini—Signalling
2337 P. R. Dreyscharff—Spinning mules
2338 D. Stevens—Obtaining motive power
2339 E. and J. M. Verity—Fixing knobs
2340 J. Finuey—Governors for steam engines
2341 F. Broughton and R. Stephens — Break block
2342 F. Laug and C. Reichert — Pressure gauges
2343 J. Gowans—Tramways
2344 H. Walker—Small arms
2345 W. E. Newton—Navigable vessels
2346 W. E. Newton—Furnaces
2347 A. Ray—Machine to dye, &c.

Dated September 6th, 1871.

2348 J. H. Johnson—Casting chilled rolls
2349 J. H. Johnson—Firearms
2350 C. H. Gardner—Printing presses
2351 R. Leybourne—Straightening metal rails
2352 J. Atkinson—Telegraph poles
2353 J. T. Cocking—Splints
2354 R. and S. Patterson—Millstones
2355 E. T. Hughes—Expansion valve
2356 A. V. Newton—Returning the products of combustion, &c.
2357 M. E. Horley—Conservatories
2358 C. H. Gardner—Printing presses
2359 W. Soper—Firearms
2360 W. R. Lake—Pickle fork

Dated September 7th, 1871.

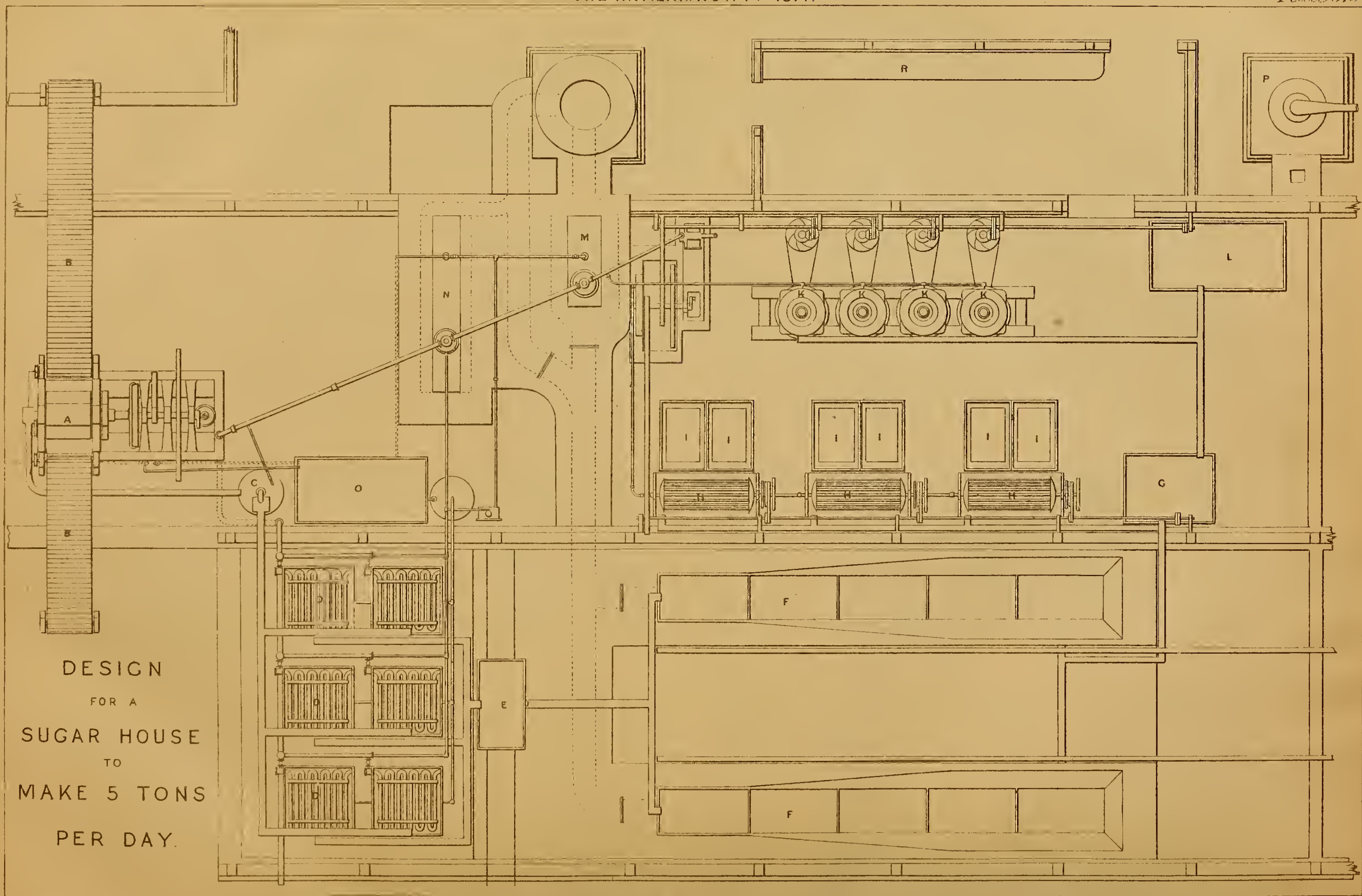
2361 E. Hulme—Loading grain
2362 C. D. Abel—Imitation of fancy patterns on cloth
2363 T. J. Smith—Clips
2364 G. White—Ceresino
2365 M. Billinghurst—Harrow
2366 L. V. Audré—Sewing machines
2367 G. F. Knowland and J. Smith—Spring mattresses
2368 D. R. Barnett—Shuttles
2369 T. D. Jermain—Printing machinery
2370 F. R. A. Glover—Hoisting heavy or cumbrous articles
2371 A. Ripley—Portable punch

Dated September 8th, 1871.

2372 J. M. Zamoyski and W. Jackson—Railway locomotives
2373 S. Smith and E. Leech—Furnaces
2374 J. Mactear—Utilising bye products of soda and potash
2375 T. A. Elliott—Construction of ships
2376 W. C. Street—Stopper for bottles
2377 W. Barber, C. Barber, and E. Baines—Card-setting machines
2378 W. Brookes—Filtering presses
2379 R. Blakemore, W. A. Sherring, and H. Horstman—Locking nuts
2380 A. M. Clark—Discharging ordnance

Dated September 9th, 1871.

2381 W. P. Goulding—Packing for steam joints
2382 E. Ear—Pressure gauges
2383 J. Fletcher—Packing rings
2384 T. Rowan—Utilising bye products of alkali



DESIGN
FOR A
SUGAR HOUSE
TO
MAKE 5 TONS
PER DAY.

P. Seames, A.K.C. direx.

THE ARTIZAN.

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1st NOVEMBER, 1871.

THE MANUFACTURE OF CANE SUGAR IN THE COLONIES.

(Illustrated by Plate 379).

(Continued from page 222.)

In The Artizan for last month we gave illustrations of various machines for cultivating the soil by steam power, and incidentally mentioned that the engines requisite for that purpose might also be employed, when not required for that object, in driving pumping machinery for irrigating the canes. The practice of irrigation is, however, so little understood, that a few remarks upon this subject may be found useful. It is perhaps not generally known that the amount of evaporation from the earth during dry weather and at a given temperature has never been satisfactorily determined. This is not so much to be wondered at when we consider the peculiar difficulties standing in the way of such determination. Thus, it would, of course, be impossible to collect and gauge the moisture given off from an acre of ground, as from the very nature of the test the ground must be freely exposed to the action of the sun and air—a condition obviously incompatible with accurate measurements. The amount of evaporation from a certain area of the surface of water has been gauged by several eminent meteorologists, such as Dalton, Howard, Daniell, &c., for a consecutive number of years, and with such uniform results that we may safely take those results as a basis upon which to make our calculations. We say as a *basis*, for as these experiments were necessarily performed under cover, where the air was motionless, and as it is an acknowledged fact that the motion of the air exercises a very important part in the evaporation of water, a large allowance must be made for those countries, such as most of the West India Islands, where a strong breeze is constantly blowing. Another great and almost insuperable difficulty in calculating the amount of evaporation arises from the state of the atmosphere. Thus, when the air is very dry, the rate of evaporation is very large, and as the amount of moisture increases in the air the rate of evaporation decreases until, when the air is saturated with moisture, no evaporation can take place. This circumstance brings us to another difficulty, viz., the temperature of the air. It is a well known fact that air has the power of retaining moisture in proportion to its temperature, and consequently we not unfrequently find that the air, which has been as bright and pure as can only be produced in a tropical cloudless sky, converted into a cloud, or, what is the same thing, a dense white fog, a few hours before sunrise; or during the cold months, shortly after sunset.

Having thus stated some of the difficulties that lay in the way of accurate computation of the amount of evaporation, we will now endeavour to give some hints that may enable the planter, knowing his own climate, to estimate the amount of water that would probably be required for irrigating a certain acreage of canes during a dry season. According to the authorities just mentioned, the amount of evaporation varies with the temperature, and the following rule, simplified, but sufficiently accurate for our purpose, may be adopted. Assuming t to be the mean temperature, $\tau = t - 6$; f the elastic of the temperature corresponding to t, and ϕ the elastic force corresponding to τ, and e the amount of evaporation, the amount of evaporation per diem will stand thus—

$$e = \left(f - \frac{81}{80} \phi \right)$$

or sufficiently near for our purpose, $e = f - \phi$.

Thus, supposing the mean temperature of the air to be 80° when the elastic force of vapour is equal to 1, the amount of evaporation would be $e = 1 - .823$, or somewhat less than .2 of an inch per day.

The above formula is for a perfectly still atmosphere, but, as we may probably assume, that the excess of evaporation due to the sun and wind, is counterbalanced by the dew at night, it will leave the total evaporation at somewhat less than 1½in. per week. This we believe to be approximately correct, as the average rain-fall in tropical climates is about the same amount, and it is to be presumed, that the supply should in ordinary seasons equal the demand. It will be seen, that the above estimates have been purposely made somewhat in excess, in order to allow for the waste necessarily incurred in irrigating.

In addition to the amount of moisture evaporated from the soil, there has, of course, to be provided a sufficient quantity of water for the nourishment of the canes. The amount thus required can only be estimated by practice. As a general rule, an extra half inch per week or two inches altogether is a sufficient weekly supply for growing canes during dry weather. It is, however, a well-known fact amongst all horticulturalists, that a "good soaking" at long intervals is better than the system of "little and often." The principal reason for this, is that when the ground is but slightly irrigated, the roots of the plants make their way upwards in search of the water. The disadvantage of this, is that the plants are less able to endure a drought than those having their roots deeper, and also they are much more liable to be laid during a storm. For this reason it is better to thoroughly irrigate a portion of the canes at a time, than to endeavour to give the whole estate a small quantity.

In the accompanying engravings, Fig. 1 illustrates a centrifugal pump adapted for the purposes of irrigation, and to be driven by an independent engine. Fig. 2 illustrates the centrifugal pump, fitted in the barge or punt already alluded to, as carrying the suitable machinery for ploughing the land. It will be seen, that the same engine which has done duty for ploughing, is now working the pump for irrigating the higher lands. The power of the engine is fully equal to working a centrifugal pump capable of delivering 3,000 gallons per minute.

As we have already observed, the amount of water required by growing canes during dry weather, is somewhat less than two inches per week. The amount of water required to irrigate an acre of land to a depth of two inches is, roughly, 45,000 gallons. Consequently, a pump throwing 3,000 gallons per minute, would take 15 minutes to perform the work. This would give 40 acres per day of 10 hours, or 240 acres per week; the machinery irrigating 40 acres one day and then moving on to the next field and so on; returning to the first field at the end of the week. As, according to the arrangements for cultivating the soil already described, two barges and engines are required upon an estate, this amount must be doubled; and consequently, the irrigating power of the machinery employed upon the estate is fully equal to serving 480 acres. Of course if the engines were worked more than 10 hours per day, a proportionately larger area might be irrigated. By the judicious use of irrigation for a few months while the canes are growing, an increased yield of at least a ton of sugar per acre, might, we feel confident, be obtained.

In Plate 379, we have illustrated a design in plan of a sugar-house complete, with the exception of the still-house, which we purpose to

treat upon in a future article. As the various apparatus here shown have already been described both as regards their form and also the processes for which they are designed, but little explanation is here required.

To begin at the beginning, the cut canes already delivered in the cane-yard, are usnally tied up in bundles by means of their own leaves, somewhat similar to sheaves of corn. These are carried to the mill where the ligature is cut and thrown on one side, and the canes spread upon the table and fed into the mill A. The quantity of canes that a good mill will absorb is very great, and the canes may be "fed in" in a body as close together as the rollers will take them. It too often happens, however, that the workmen throw in the canes, in a lump instead of distributing them across the length of the rollers. This should never be allowed, as it not only brings an undue strain upon the mill, but smashes up the "trash" or "megass" at that spot, and allows the few canes traversing the comparatively unoccupied spaces to go through without being sufficiently squeezed. In order to remedy this defect, a cane carrier (B), is frequently used, which, as it affords a more extended surface upon which to place the canes, they can be more evenly distributed before arriving at the jaws of the mill.

trated to a density of about 27° Beaumé. From these batteries it is let down to the Wetzel pans, H, or if they are full, into the cistern, G, whence it is pumped up into the Wetzels as required. When concentrated in the Wetzels, the syrup is allowed to run into the coolers, I, by means of movable gutters, not shown in the plate. Here it is allowed to stand for abont 24 hours to crystallise, when it is dug out and dried in the centrifugal machines, K. The molasses or uncrystallised portion of the sugar is allowed to run along the gutters, shown in Plate 379, either into the cistern, G, or the tank, L. If the molasses is from first qnality sugar, it is frequently run into the cistern, G, and thence pumped up into the Wetzels and re-concentrated. If, however, it be not good enough for that purpose, it is run into the tank, L, and drawn off into the still-house as required.

The sugar, after being cured in the centrifugal machines, is taken to the sugar table R, and either packed at once into boxes or hogsheads, or exposed to the sun and still further dried. If the sugar has a clean, bold grain, it reqnires no further drying after it comes from the centrifngal, bnt if it is soft and pasty it is better to expose it to the sun for a day or two before packing.

Fig. 1.

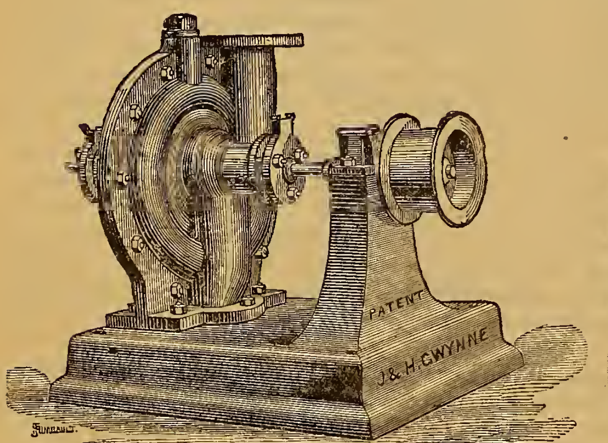
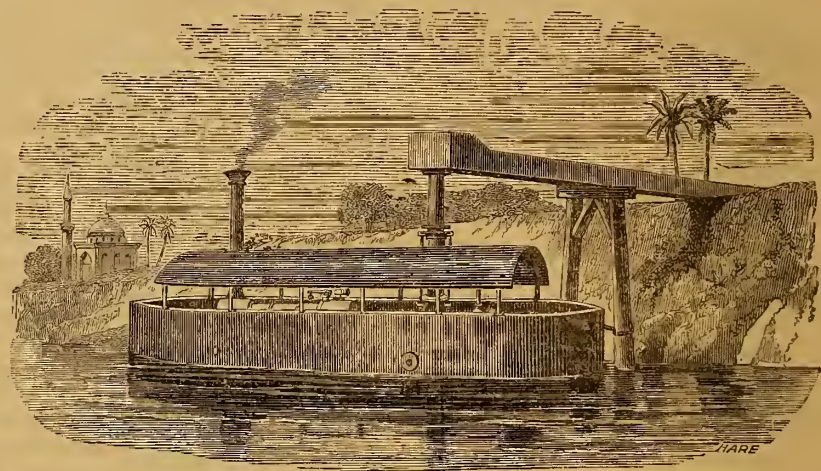


Fig. 2.



The canes—or rather what is left of them—after passing through the mill are in a state somewhat like millboard. This is usually carried away either into a trash-honse, or if the weather be very fine, spread over the yard to dry; and when dry, it is used as fuel for the evaporating pans. As this process involves a considerable amount of labour, "trash" or "megass" carriers (B), are sometimes employed, by which means the crushed cane is carried to the top of the trash-house. The trash-house, a small portion of which is shown in Plate 379, is usually a long narrow building, composed of upright columns of brick or stone, and covered with a galvanised iron roof. A tramway upon which a small truck runs, is formed along the middle, and as high np as the roof will admit. The trash elevator being placed so as to deliver the refuse canes into the truck, this may be run along the tramway, and discharged at any point that may be desired.

The cane-juice runs along the gutter to the monte-jns, C, where it is clevated into the clarifiers D, as already described. The liquor when clarified passes along gutters as shown, to the shallow charcoal filter, E, described in The Artizan, of December last, p. 270. This filter runs npon a tramway, and when the charcoal becomes saturated with the impurities of the liquor, may be run out, and another similar filter already charged run in, to take its place. In most sngar-houses this filter is not used, but the liquor rnn directly into the evaporating pans. We think, however, that it is exceedingly usefnl, and as it is also very simple its use should not be dispensed with. From the filter, E, the juice runs to the evaporating pans or batteries, F, where it is concen-

The boiler shown at M is heated from the waste heat from the batteries F, the flnes of which, as shown in the dotted lines, pass through it. This boiler is cylindrical, about 6ft. 6in. in diameter, and 7ft. in length. It is similar to a tubular boiler without any furnace, the lower portion to within about 6in. of the surface of the water being filled with 3in. tubes. As the waste heat from the batteries is necessarily very great, in consequence of the necessity of keeping up a fierce boil the whole time they are in operation, it is of the ntmost importance that it should be utilised. By means of a tubular boiler placed in the flue, as shown in Plate 379, this is done very effectually; in fact, a short time after the batteries are started the fire in the common boiler N may be stopped, as a sufficient amount of steam can be raised for the entire work of the sugar-house from the boiler M alone. The condense water from the clarifiers and Wetzels runs into a small cistern J, to which is attached a donkey-engine for feeding the boilers, and in order to make np any deficiency in the amonnt, this cistern may also be fed as required from the cold-water tank O, placed on colnmns above the clarifiers, and supplied from the feed-pump of the mill. This cold-water tank is also very useful in supplying water for washing out the clarifiers, batteries, Wetzels, &c., as often as necessary.

It will be seen from the above description that but little pumping, and no manual labour is necessary for raising the cane-juice. Thus, when the juice runs from the mill it enters the monte-jus, where it is once for all raised a sufficient height to run into the clarifiers, which are elevated abont fifteen feet from the ground. From the clarifiers it runs, by its

own gravity, first into the charcoal filter, thence into the batteries where it runs from one compartment to another through valves; thence to the Wetzels, and thence into the coolers. By this means a considerable saving of labour is effected over the old method of ladling from one pan to another.

(To be continued.)

ON THREE MASSES OF METEORIC IRON FROM AUGUSTA CO., VIRGINIA.

By J. W. MALLET.

Nearly two years ago I learned that a lump of iron, which from the description given of it I supposed to be meteoric, had been turned up by the plough in Augusta Co. in this State, and soon afterwards I obtained possession of this specimen by the kind assistance of Hon. J. B. Baldwin, of Staunton. It proved to be beyond question a meteorite, weighing about 56lbs. A few months later, I saw at the annual fair of the State Agricultural Society in Richmond, a second mass, of smaller size, weighing about 36lbs., which had come from the same county, and was exhibited along with some iron ores by Major J. Hotchkiss, of Staunton. Learning from me that I was about to examine and analyse my own specimen, and was anxious to compare it with the other found in the same part of the country, Major Hotchkiss was obliging enough to lend me the latter, and to permit me to cut off enough for analysis. Quite recently he has placed in my hands a third specimen—also from Augusta Co.—weighing but about 3½lbs. I shall speak of these three masses as No. 1, No. 2, and No. 3, in the order in which they are mentioned above; No. 1 being my own specimen, and Nos. 2 and 3 those of Major Hotchkiss. All three present quite the same general appearance. They are of a very irregular pear shape, one end of each mass being larger and more rounded than the other—the smaller end of each is somewhat flattened, but by concave sufaces, in one direction. No. 1 was more massive and rounded than the others—No. 2 most flattened—the latter had some rude resemblance in shape to a shoulder of mutton. The dimensions of the masses before cutting were as follows :—

	No. 1. Centimetres	No. 2. C.m.	No. 3. C.m.
Maximum length	28	27	11
„ width, at large end	21	10	9
„ „ at small end	17	19	5
„ thickness, at large end	13	13	8
„ „ at small end	11	5	3

The exact weights before cutting were :—

No. 1.	No. 2.	No 3.
25,429 grms.	16,441 grms.	1644 grms.

the masses being entire, nothing having been previously detached from any one of them. The surface of each of the masses is rough and irregular. At some points, which have been rubbed, the iron exhibits its metallic lustre, and traces of its crystalline character may be observed, but nearly the whole surface is covered with a dark brown crust, consisting essentially of hydrated ferric oxide, which varies from about an eighth to a third of an inch in thickness. This crust is hard, and pretty firmly adherent. On exposure to moist air a rusty liquid exudes in drops from numerous points upon the surface, and in this watery liquid chlorine, iron (chiefly as ferrous chloride), and nickel were detected. The masses are of course magnetic, and on examination give evidence of feeble magnetic polarity, with multiple poles. The union of hardness and toughness in the iron makes it quite difficult to cut, and in attempting to obtain with the planing machine a slice of considerable size the ordinary cutting tools were blunted and broken; it was found necessary to drill a row of holes and connect these by a cut made with the planer. The specific gravity was taken for Nos. 1 and 2 with solid pieces of about 140 grms. and 95 grms. respectively, cut from the interior of the masses, and for No. 3 with about ten grms. of clean shavings (from the planer) in a specific gravity bottle. The results were :—

	No. 1.	No. 2.	No. 3.
Specific gravity, at 15° C.	7·853	7·855	7·839

The interior structure of the iron is compact and highly crystalline, of much the same general character throughout, but a few small grains and streaks of a brownish yellow mineral were noticed, which on being picked out and examined proved to be troilite. There are, however, minute fissures running through several portions of the metal. Traces of the Widmannstättian figures may be detected upon a polished surface even without the aid of an acid, and when the iron has been etched by nitric acid the markings are exceedingly distinct and beautiful, fully as much so as in any specimen of meteoric iron I have ever seen. The general appearance is a good deal like that of the iron from Lenarto in Hungary, and some of the Mexican specimens. In the mass No. 1, upon the principal cut surface, narrow, well-defined bands of alternate nickel-iron and Schreibersite are parallel or intersect each other at angles of about 60° and 120°; in the figures on the principal surface of No. 2, the angles of intersection more nearly approach 90°: on the much smaller cut surface of No. 3, the figures are somewhat more irregular, but the angles approach 60°. By etching surfaces obtained in other planes it was rendered evident that the difference of appearance is merely due to looking at different projections of the same crystalline structure. The metal soon rusts upon cut surfaces, especially where the exudation of chlorine occurs, and this renders more distinctly visible the slight fissures which penetrate the interior. The iron is not passive, though very easily rendered so by nitric acid. It reduces copper rather slowly from the sulphate, and if the whole surface be covered by the latter metal and then washed under a stream of water, rubbing hard with the hand or a cloth, a part of the copper comes off very easily, leaving the remainder firmly attached and reproducing very beautifully the Widmannstättian figures, obviously a case of galvanic deposition, the Schreibersite being the electro-negative solid and receiving the coating of copper. By the prolonged action of acid delicate white laminæ of Schreibersite are brought into view, which if completely detached are found to be flexible and strongly magnetic.

The following are the results of chemical analysis :—

	No. 1.	No. 2.	No. 3.
Iron	88·706	88·365	89·007
Nickel	10·163	10·242	9·964
Cobalt	0·396	0·428	0·387
Copper	0·003	0·004	0·003
Tin	0·002	0·002	0·003
Manganese	trace	—	trace
Phosphorus	0·341	0·362	0·375
Sulphur	0·019	0·008	0·026
Chlorine	0·003	0·002	0·004
Carbon	0·172	0·185	0·122
Silica	0·067	0·061	0·056
	99·872	99·659	99.947

These numbers are so closely accordant that there can be no doubt of the masses being essentially identical in chemical composition. The nickel and iron were separated, in a cold and quite dilute solution, by means of carbonate of baryta, and the precipitates obtained were carefully tested as to purity before the weights were finally accepted as correct. Considerable quantities of material were used for the determination of the minor constituents. Particular attention was given to the identification of the minute quantity of tin present, as Professor J. Lawrence Smith has lately mentioned the fact, that he has never found this metal in the course of numerous analyses of meteoric iron. The precipitate with sulphuretted hydrogen, which contained the tin and copper, was in each case obtained from a solution of more than a hundred grms. of the iron. I feel satisfied that the chlorine is not of meteoric origin—not an essential constituent of the original masses—but has been derived from the soil in which the iron has lain imbedded, The exudation of watery drops containing metallic chlorides is observable only at points on the outside and on cut surfaces along the lines of fissures communicating with the outside. Although chlorine is mentioned above as found in the general analyses of the planing machine shavings I failed altogether to detect it in specially selected solid piece of some 50 grms. taken from a part of No. 1 destitute of fissures or flaws. The siliceous residue is set down as silicic acid, but some of it seems to have in reality existed as silicide of iron. A part of this residue having been examined with the blowpipe to identify it as silicic acid, another portion was looked at with a magnifying power of 250 to 500 diameters, and in polarised light was seen to consist of an amorphous powder, and rounded, transparent grains of very small dimensions, for the most part from 0·0025 to 0·0100 millimetre in diameter, of well-marked doubly refracting character. It seems in the highest degree probable that these three masses of meteoric iron represent portions of a single fall from the heavens, agreeing so closely as they do in external character and appearance, in density and internal structure, and in chemical constitution; having, moreover, all been found at but short distances from each other. The precise localities from which they came are as follows :—No. 1, from a spot on the land of Mr. Robert Van Lear, about five miles (a little east of) north from Staunton, in 38° 14′ N. lat. and 79° 10′ W. long.; No. 2, from the land of Mr. M. Fackler, about one mile to the south-east of the locality of No. 1.; No. 3, about half a mile still further south-east, or rather a little north of a N.W. and S.E. line passing through the last-named locality. It will be interesting to watch for the possible detection of other masses in the same neighbourhood. This makes the fourth recorded instance of meteorites found within the State of Virginia,

the three preceding having been:—1. Meteoric stone, which fell in Chesterfield Co., June 4th, 1828; 2. Meteoric iron, found in Grayson Co., described by Professor Rogers of this University in 1852; 3. Meteoric iron, found in Roanoke Co., and described by Professor Rogers in 1842.

THE NEW STEAMER "MOSELLE."

This fine vessel, built and engined by Messrs. John Elder and Co., of Glasgow, for the Royal mail (West India and Brazil) Company, had an official trial on September 28th, at the measured mile in Stokes Bay, under the command of Captain T. A. Bevis. The *Moselle* is a sister ship to the *Tagus*, constructed by the same builders, and now running on the West India station. Her leading dimensions are.—Extreme length, 372ft. 11in.; breadth, 40ft. 8in.; depth, from floor to spar deck, 33ft. 9in.; and about 3,200 tons register. The engines, which are on the compound principle, are of 600-horse power (indicating 3,017 during the trial); cylinders, 60½in. and 112in. diameter respectively, with 4ft. stroke; and eight boilers, having two furnaces each, producing a bountiful supply of steam to keep the machinery going at a continuous high speed. With an average pressure of 55lb. of steam, vacuum 27in., and 61⅞ revolutions of engines, the *Moselle* ran the mile four times as follows:—First run 4 min. 25 sec., equal to 13·091 knots per hour; second, 3 min. 33 sec., 16·901 knots; third, 4 min. 48 sec., 12·500 knots; fourth, 3 min. 29 sec., 17·225 knots; the result showing a common mean speed of 14·929. knots per hour, the Government average being 14·816 The first and third runs were against both wind and tide, a strong easterly wind blowing all the time with a force of 6 to 7, and the rate of tide about two miles an hour. A more unfavourable day for the trial trip of a new steamer could not well be conceived, and the Admiralty surveyors expressed great satisfaction with the excellent performances of the vessel. The vessel had a total weight on board, of coals, water, and stores, of 1,005 tons, and her draught of water was 18ft. 7in. forward, and 20ft. 9in. aft. The machinery worked admirably throughout the day, and scarcely any vibration was felt in any part of the ship. Captain Mangles, Admiral Young, and several other directors of the company were present at the trial. Another large screw steamer, building for the company, by Messrs. Denny, Bros., named the *Boyne*, will be ready shortly.

LIGHT ROLLING STOCK FOR RAILWAYS.

On the 29th of September a party of engineers and other gentlemen interested in the construction and maintenance of railways visited Bristol for the purpose of inspecting a new double bogie locomotive and some light rolling stock, all constructing after the designs of Mr. Fairlie. The engine "Hercules" is for the Iquique Railway in Peru, and is of the same general character as those previously described in The Artizan. It has four 15in. cylinders, of 22in. stroke, and its total weight (60 tons) rests upon 12 wheels, arranged in two groups of six, coupled together, and all assisting in the adhesion. . It will be required to work heavy traffic over a gradient of 1 in 25 for 11 miles, and round curves of three chains; and during the experiments it went round curves of 2½ chains with the greatest facility, the deflection of the centre of the leading bogie platform from the end of the boiler amounting to 14in. It was then taken through a boiler shop and a smith's shop, and so upon a very irregular and badly kept piece of line belonging to the Midland Company. Here its trip was restricted by certain bridges and platforms which it could not pass; but it ran up and down, over a length of about a quarter of a mile, with the perfect smoothness for which the double bogie is so remarkable. Its passage over roughly-laid points was distinctly audible to those riding upon it, but communicated no jolt to the driver's platform. It has been built by the Avonside Company, for Messrs. Montero, of Peru.

The light rolling stock is being made at the shops of the Bristol Waggon Company; and the specimens exhibited were for three different gauges, one of 4ft. 8½in. (the prevailing gauge of this country and of Europe), one of 3ft. 6in., and one 2ft. 6in. The 3ft. 6in. stock has been made for the Dunedin and Port Chalmers Railway, and the 2ft. 6in. stock for a railway in Peru, it being intended that both lines should be worked entirely with Mr. Fairlie's carriages and engines, and upon the system for which he has so long contended.

The whole of the stock furnished ample evidence how little the capacity of carriages and waggons need be diminished by even a considerable reduction in gauge. The light waggons for the 4ft. 8½in. or ordinary narrow gauge are 14ft. long and 7ft. wide by inside measurement. Their sides are 2ft. 6in. high, they weigh 2 tons 5 cwt., and will carry seven tons. If fitted with a patent break, their weight will be increased to 2 tons 7 cwt. The 3ft. 6in. waggons are six inches longer than the foregoing, and of the same dimensions in all other respects. They weigh about 2 tons 2 cwt., and will carry seven tons. The 2ft. 6in. waggons are 6ft. wide by 12ft. long, and 2ft. 6in. deep; they weigh 1 ton 11 cwt., and will carry five tons.

The passenger carriages for the 3ft. 6in. gauge are commodious. A first-class carriage is 19ft. 6in. long, and 7ft. 6in. wide. It is divided into three equal compartments, each with seats for eight persons, and the height from floor to roof in the centre is 6ft. 8in. The roof is lined over the seats with thin mahogany, and over the centre with bird's-eye maple, and the lamp is wholly above the roof level, countersunk, so to speak, within a polished reflector, calculated to light up the whole interior and to render reading possible. The general trimmings and decorations of the interior are very tasteful and pretty. The second-class carriage is 18ft. 6in. in length, but of the same width and height as the first-class, and divided in the same manner, although each of its three compartments will accommodate ten persons. The weight of the first-class carriage is 300lb., and that of second-class carriage 232lb., for each seat; so that, if this stock can only be filled, the ordinary proportion between dead and paying weight in a passenger train will be very materially modified. The covered goods waggons for the same gauge are 14ft. 6in. long, 7ft. wide, 6ft. high, and weigh 2 tons 15 cwt.

The chief difficulty in the way of designing a light railway stock is the amount of solid material that has hitherto been thought necessary in order to give sufficient strength to resist the shocks and concussions incidental to the daily working of a line. In ordinary goods waggons, for example, the buffers are only the sides of the frame prolonged, and every time these buffers meet the whole of the frame is rudely strained and shaken. That which may thus be seen to happen at any station when a goods train is being shunted happens also, although in less degree, with passenger carriages; and the great strength, of which great weight is the necessary consequence, has been required as a protection against sudden contacts, and in order to prevent the stock from being shaken to pieces by the jars to which it must be subjected. As a first step towards lightness Mr. Fairlie has aimed at diminishing concussions, and for this purpose he has introduced a new system of buffers and of coupling. Beneath the frame of each carriage there runs a drawbar, and the drawbars of adjacent carriages are closely coupled by a single link. Every carriage is furnished at both ends with a single central buffer, presenting a convex surface, and those buffers are brought almost into contact. Each buffer is furnished with a very strong coiled spring, and has about an inch of play, the general result being that the closeness of the coupling and the continuity of the drawbar render the train of carriages movable as a single mass, and not as a succession of detached portions, which may be knocked about almost independently of each other. The passage of the united train round curves is provided for in the mode of attachment of the drawbar under each carriage, and the closeness of the coupling has rendered necessary a total departure from the ordinary mode of fastening, by which so many railway servants have been killed and injured. In the new carriages the drawbar terminates in an expanding cup or receptacle, comparable to a funnel, only square instead of circular. Through the sides of this receptacle a horizontal bolt passes, and can be moved in or out by a lever and bell-crank working from about the middle of the carriage. When two carriages are to be joined, a single iron link, about 8in. in length, is put into the receptacle of one of them and the bolt is shot through it. The carriage, with the link projecting, is moved up to its yokefellow, and the free end of the link enters the receptacle of the second carriage, where it also is secured by shooting the horizontal bolt. The expanding character of the receptacle secures the entrance of the link if it should droop a little, or if the carriage to which it is attached should be sunk upon its springs, by a heavy load, to a slightly lower level than the other one. The fastening is effected instantaneously, by a single movement of the lever, as the carriages come into position, and is not only much more expeditious than the present system, but seems to be absolutely free from danger to those who are concerned in carrying it out. If these plans are found to work in actual practice as well as they do in experimental trials, the new buffers and couples will not only save enormous expenditure in the conveyance of dead weight, but they will also save many valuable lives.

The double bogie engines for the Peruvian line of 2ft. 6in. will be required to work over long gradients of 1 in 20, and round curves of 2 chains radius. It is estimated that they will do this at 30 miles an hour, and that they will be equal to any traffic which a railway can be called upon to undertake. We learn also that various English engineering firms have now double bogie locomotives in course of construction, to the number of nearly 50, for lines, mostly of narrow gauge, in Peru, Mexico, Canada, Nova Scotia, New Zealand, Russia, Sweden, and Brazil.

THE TUNNEL BETWEEN DOVER AND CALAIS.

Now Mont Cenis is pierced successfully, and Africa converted into an island by the Suez Canal, it is fair to ask how long "the wet ditch," known as the English Channel, is to continue to be a nuisance or a terror to the continental traveller. The numberless projects which have been started, the schemes which have been discussed, the commissioners and reports, the interviews with exalted personages, the flattering announcements from time to time of the only infallible remedy for sea-sickness on the journey between Dover and Calais having been discovered—have none of them helped the people who have gone abroad this year. The waves have been as productive of unpleasant consequences, the boats as wretched, the passengers as limp and miserable as ever; and with the triumphs of French and Italian engineers freshly before the world, it seems natural to ask whether the countrymen of Stephenson, Brunel, and Telford are contend to be defeated by the "silver streak of sea." The answer is easy. The Franco-German war has interfered with the projects for joining Great Britain with the Continent, and delayed their fruition, as it has many another scheme of progress. At this moment it is chiefly the formal grant of a concession from the French Government which the advocates of a tunnel between the two countries are waiting for. This granted, the public will assuredly hear more of the Channel tunnel. In Lord Clarendon's lifetime the French authorities were about to grant the concession, and wrote to the English Foreign-office to ask if our Government had any objection to offer. There was an interview between Lord Clarendon and Lord Richard Grosvenor, M.P., the chairman of the International Committee for considering and reporting on the practicability of constructing a tunnel between England and France, after which an official letter affirming the high respectability of the members of the committee was despached from the Foreign Offices, and then the matter hung fire for the time. The Continent was convulsed soon afterwards, and the French Government has scarcely been in a position to grant concessions for the easier occupation of the country. The delay has been employed by those interested in promoting a Channel tunnel in strengthening their hands, and in confirming the convictions they had formed.

It was at the suggestion of the Emperor Napoleon that an International Committee was formed in 1867, to organise plans for a tunnel between England and France. In June, 1868, this Committee, together with its engineers, had an interview with the then Emperor, in the course of which copies of the reports and plans, together with an address in favour of the project, signed by many peers, members of Parliament, and other representative men, were laid before his Majesty, who referred the matter to the favourable consideration of the Minister of Public Works, who in his turn appointed a Special Commission to inquire into the subject in all its bearings. This Commission made its report in March, 1869, and the opinion of the General Council of Mines and Bridges pronounced upon it in the same month, while that of the General Council of Mines was laid before the Emperor a few weeks later. It was subsequent to these repeated investigations and reports that the French Government applied formally to that of England to know if there were any reason why a concession should not be granted for carrying out the works. The following general conclusions were submitted to the International Committee, in a report, dated June, 1868, and signed by the following eminent English and French engineers:—John Hawkshaw, James Brunlees, William Lowe, Paulin Talabot, Michel Chevalier, and Thome de Gamond:—

"1. That there is a reasonable prospect that the work can be accomplished, but that it would be improper to deny that it is attended with a certain amount of risk.

"2. That this risk is limited to one contingency—viz., the possibility of sea-water finding its way by some unforeseen fissure into the workings in quantities too great to be overcome. Apart from this risk, tunnelling in chalk is easy and rapid, and the execution of a tunnel of the length of the one under consideration is only a question of time and expense.

"3. There seems to be no reason to assume that the tunnel would cost more than ten millions sterling, or that it could not be completed in nine or ten years.

"4. The question of risk would be fully solved by sinking land shafts on each coast, and driving the preliminary driftways. This portion of the work being safely accomplished, the remainder would be of an ordinary character.

"5. The possible loss would be measured by the cost of this preliminary work, which we estimate at one million and a-half, and which could not exceed two millions, or say one-fifth of the whole cost of the tunnel.

"6. That this risk should be undertaken by the governments of France and England, if after the consideration they deem the importance of the work and the probability of its completion suffioient to justify them in doing so."

The French Commission, in a report dated March, 1869, and signed "Ch. Combes (Prosident of the Commission), Kleitz, A. Coupvent des Bois, De la Poncié, E. de Hennezel, L. Lalanne, and A. de Lapparent (secretary and reporter), are of opinion that driving a submarine tunnel in the lower part of this chalk is an undertaking which presents reasonable chances of success. Nevertheless, they would not hide from themselves the fact that its execution is subject to contingencies which may render success impossible. These contingencies may be included under two heads;—Either in meeting with ground particularly treacherous—a circumstance which the known character of the grey chalk renders improbable, or in an influx of water in a quantity too great to be mastered, and which might find its way in, either by infiltration along the plane of the beds, or through cracks crossing the body of the chalk. Apart from these contingencies, the work of excavation in a soft rock like grey chalk appears to be relatively easy and rapid; and the execution of a tunnel, under the conditions of the project, is but a matter of time and money."

The following extract from the engineers' report has special significance, now that travelling between Switzerland and Italy occupies no more time than from Waterloo to Wimbledon, or from the City to the West-end:—"It is evident that at some sufficient depth below the bottom of the Channel a tunnel could be constructed, so that as regards superincumbent pressure only, it would be analogous to constructing a tunnel of similar length through a mountain so high as to prohibit intermediate shafts; and it is evident that any possible irruption of sea water may be avoided by going deep enough below the bottom of the Channel. On the other hand, there is a limit to the depth at which the tunnel can be carried, from the necessity of approaching it from the shore, and obtaining gradients for those approaches suitable for railway traffic.

About two months ago, another communication from the French authorities was replied to by the English Government; and the formal concession is now expected, with exclusive rights and privileges to those who construct the tunnel. It is pleasant to remember in this connection, that Mr. John Hawkshaw is the English engineer who pledged himself years ago to the success of the Suez Canal, and upon whose report the late Viceroy, Said Pasha, permitted the work to proceed. Mr. John Fowler and others came in towards the conclusion of the fight, when there was little else to do than to cheer the victors; but Mr. Hawkshaw spoke out boldly, and pinned his professional reputation to specific predictions, when to talk in England of the possible success of the Suez Canal was to run some risk of being branded as a traitor or a visionary. When, therefore, Mr. Hawkshaw's name is the first name appended to the proposals for boring a tunnel between Dover and Calais, the Egyptian precedent has considerable weight; and the soundness of his views as to piercing through the desert gives credit to his opinion as to burrowing under the sea. But in truth the weight of testimony as to the practicability of a tunnel under the Straits of Dover is exceptionably strong. The mining engineers point to Whitehaven and Northumberland, where galleries are worked undea the sea, which occupy in their manifold turnings many times the distance between England and France. The theories as to the difficulty of ventilating a tunnel of twenty miles are disposed of easily. The towers or air-shafts, standing like lighthouses in mid-ocean, are no longer thought to be necessary. The difference in temperature between the two ends of a tunnel is the greatest security for its ventilation; and many authorities insist that, so far from air-shafts being essentials, they defeat the ends for which they are designed. The Mont Cenis Tunnel, and the perfect current of air maintained there, are striking examples of what may be done without them.

It must not be supposed that the International Committee have been idle during their twenty months of waiting, or that those members of it who will be directly or indirectly interested in the company which will be formed when the French concession is received have been contented to fold their hands. The reports quoted and other evidence cause them to regard the perfect practicability of the Channel Tunnel as a foregone conclusion. It is on the details by which the scheme shall be carried out rapidly and cheaply, that attention has been concentrated lately. There are eight hundred feet in depth of chalk under the sea between Dover and Calais. Chalk can be worked as easily as a Dutch cheese, of which, or of good pipe clay, its consistency reminds the investigator. The well at Harwich, at Dover, and at Calais are said to prove this geologically, and a new tunneling machine which was exhibited at the meeting of the British Association last year, and which the International Committee have seen at work for months upon the chalk at Snodland, near Rochester, testifies to the rest. This machine will, and does make a hole seven feet in diameter, and eighteen yards forward in the chalk strata in every twenty-four hours. This being so, what are called the driftways of the proposed tunnel can, it is maintained, be driven in one year instead of five, as was calculated, and the enlargement and completion will follow in two or three years more. One of the favourite proposals is that there shall be two driftways and two separate tunnels,

so that the trains shall always travel the same way in the same tunnel. This would not be more expensive, for the difference in cost through reduced size would fully compensate for the duplicate tunnel; and while a very short time ago ten millions was put down as a probable cost, the statistics and success of the Mont Cenis Tunnel cause many competent people to reduce that figure considerably.

TO INDIA IN FIVE DAYS.

Another attempt to solve the problem of direct railway communication between England and India has just been made by Messrs. William Low and George Thomas, of Wrexham and Cardiff. Under the form of a letter to Mr. Gladstone these gentlemen have published an outline of their plan, and it deserves the attentive consideration of the public.

The route now open between England and India which admits of making the journey in the shortest time is that by way of Brindisi, Alexandria, and Suez to Kurrachee or Bombay. The absolute distance is greater than by the route from Marseilles to Alexandria, but the advantage gained from the greater length of the railway portion more than compensates in time for the increased distance that is travelled. The whole journey is supposed to take 20 days, although it is seldom actually completed within this limit.

The proposal of Messrs. Low and Thomas is to make use of existing lines of railway and of the Mont Cenis Tunnel to Trieste, and thence to construct a railroad through Austria, European and Asiatic Turkey, Persia, and Beloochistan, to Kurrachee, and onwards to Bombay.

On leaving Trieste, the projected line would pass by Fiume to the eastern shore of the Adriatic, and run southwards along this shore to a point nearly opposite Brindisi. From here it would turn directly eastward, across Turkey, and to the north of the Archipelago and the Sea of Marmora, to Constantinople. Crossing the Bosphorus, it would turn southward at Scutari, and reach the Mediterranean at Adalia. From Adalia to Alexandretta it would skirt the coast; and from Alexandretta would pursue a south-easterly course to the western extremity of the Persian Gulf. From this point it would follow the shore of the Gulf, and of the Arabian Sea, to Kurrachee. The route thus briefly sketched is given in much more detail by the authors, who include in the plan a branch from near Antioch to Jerusalem, and a branch to join the Smyrna and Aidin Railway.

Without considering these branches, the total distance from London to Kurrachee would be 5,311 miles by rail, and 28 miles (the Straits of Dover) by sea. At a uniform rate of $10\frac{1}{2}$ miles an hour by water and 40 miles an hour by land the journey from end to end would be accomplished in 5 days, 16 hours, 46 minutes. Calculating the railway travelling at 30 miles an hour the time would be 7 days, 13 hours, 22 minutes; and at 50 miles an hour, 4 days, 10 hours, and 13 minutes. Of the total length of line required nearly one-fourth (1,170 miles) is already constructed.

The highest estimated cost of the undertaking is in round numbers 41 millions sterling, and the estimated cost per mile ranges from £8,000 to £17,000 in different localities. The gross estimate for the several sections is as follows:—

In Austria	£6,545,000
In Turkey in Europe	7,224,000
Steam-ferry across Bosphorus	100,000
In Turkey in Asia	14,670,000
In Persia	6,840,000
In Beloochistan	5,392,000
In Scinde	184,000
	£40,955,000

The authors suggest that the cost of construction should be borne not by one nation only, but by all through which the line would pass, and they assume that to bring the 175 millions of India within five days' journey of England would be a source of enormous through traffic, as well as of traffic between various intermediate points. Their suggestion is that there should be an Anglo-Indian Company, responsible for the construction and maintenance of the through permanent way, and a group of subordinate companies responsible for the construction and maintenance of all stations, sidings, and other works required for the local traffic to, from, or within, each country that would be traversed. Under such an arrangement the through train from Calais to Kurrachee would take precedence of trains running shorter distances, these being shunted to make way for it; but, with this reservation, each local company might run its own trains between the termini and any point in its own territory. Thus the Turkish company would be at liberty to run between Calais and Constantinople or between Constantinople and Kurrachee.

The authors are fully persuaded of the feasibility of the plan for constructing a submarine tunnel between England and France, and believe that such a work is likely to be accomplished. But, leaving this prospect out of consideration, and assuming that passengers and mails would be conveyed by ordinary carriages and boats from London to Calais as at present, they continue:—

"After leaving Calais the through trains should not stop before arriving at Paris, and then only for a few minutes, for the purpose of attaching and detaching carriages and changing locomotives. The next stopping-place ought to be Turin, after that Trieste, then Salonika, after that Constantinople, and then near Antioch, then Bagdad, Bushire, some town in Beloochistan, and lastly Kurrachee. In addition to these other stations would be fixed upon, for the purpose of changing the locomotive.

"Another daily through train would start from Paris, stopping at the same stations as the through train from London. Another daily through train would start from Turin, stopping at the same fixed stations; another from Trieste, another from Constantinople, also Antioch, Bagdad, and Bushire, each starting daily for Kurrachee. Thus we should have an English, French, Italian, Austrian, Turkish, and Persian through train, leaving for India every day, and trains leaving India for each of these places respectively, with other trains between each of them and other important stations on the route."

The projectors conceive that the great difficulty that has to be overcome is the formation of companies and the raising the necessary capital for constructing the lines of railway in the different countries through which it is proposed to pass, and they think this could be surmounted if the Governments of these countries were to take an active part in the matter. They assume as not needing demonstration that the traffic would yield an adequate return for the outlay; but they omit to point out the necessity there would be for a guaranteed protection of the line as an absolutely neutral and peaceful territory in the event of war breaking out along its track, or in any of the countries through which it would pass.

The projected line presents no particular difficulties of construction in the way of the permanent works that would be required; and its proximity to the seaboard for three-fourths of its course would afford great facilities for the conveyance of materials. On the supposition that a year would be required for preliminary inquiries and for the granting of concessions, the authors assert that the whole undertaking might be completed and at work within three years from the present time.

We do not at present intend to express any opinion upon the practicability of the scheme thus sketched in outline. The difficulties in the way of its accomplishment would necessarily be great, but we lack *data* for an opinion as to whether they would be insurmountable. They would probably depend far more upon the arrangement of details and upon conflicting claims and interests than upon the gigantic character and enormous cost of the undertaking; and we presume there can be little doubt that, at some not far distant period, direct railway communication between this country and India must be established at whatever outlay. There is one point, however, which the authors of the pamphlet have sought to dispose of in 20 lines, but which needs much consideration. We refer to the gauge on which a railway to India should be constructed. They say:—

"An important point in discussion at the present moment is in reference to the gauge, so as to economise as much as possible in the construction of the works. We are of opinion that the present gauge of 4ft. $8\frac{1}{2}$in. is the one which should be adopted for a through railway to India. It is the gauge of the existing railways both in England and on the Continent, besides being the gauge of the present main lines in India. The gauge of 3ft. 3in., as adopted by the Governor-General of India for the extension of minor lines in that country, or the still narrower gauge of the Festiniog Railway, in lessening the works of construction and the cost of rolling stock, will admit of railways being made where the present gauge would never pay. Such a small gauge is especially adapted for islands such as Corsica, the Isle of Man, &c., and while we admit this, and advocate the adoption of such lines under particular circumstances, we nevertheless consider that to obtain the speed and power necessary for working so large a traffic as that which will flow along this railway, uniting the nations of Europe and India, the existing gauge must be maintained."

Now, there must be some width of gauge which is the best for the purposes of ordinary traffic, by reason of its combining the greatest number of *desiderata*; and it is very unlikely that this width should be precisely 4ft. $8\frac{1}{2}$in. a measurement which originated in the accidental length of somebody's cart axle. We may fairly assume that some better width might be arrived at by calculation; and if so, the existing gauge has only the fact of its existence to recommend it. We do not think that this fact will justify engineers in imposing it upon a new and prodigious undertaking, more especially when we consider that the best attainable

gauge, if we could discover and make it, might be expected eventually to supersede all others, and to become universal, as railways in course of time were repaired and re-laid. Mr. Fairlie, in his papers read before successive meetings of the British Association, has maintained that a gauge line, *plus* a very powerful engine, elongated and running on bogies, possesses enough carrying capacity to work the whole traffic of the London and North-Western Railway far more cheaply than it is worked at present. He maintains, also, that a gauge of 3ft. will carry the best possible rolling-stock—that, namely, in which the floor area, the weight, and the carrying capacity are such as to afford the smallest possible proportion of dead to paying load; and he asserts that a speed of 40 miles an hour may be accomplished on such a gauge, with perfect security. He tells us that the economy of constructing a line of 3ft. gauge, although not inconsiderable, sinks into nothingness when compared with the perpetual economy of working it; and the Imperial Livny Railway in Russia, recently completed in accordance with his plans, seems, so far, fully to bear out his statements. His arguments, if not unanswerable, have at least not been answered; and they have so far convinced Americans that the course of another year will see nearly 6,000 miles of Fairlie railway in operation in the States, much of it (as for example a new line between New York and Philadelphia) actually constructed to compete with lines of broader gauge that are at present existing and working in absolutely the same districts.

A gauge narrower than 4ft. 8½in. would, of course, involve a break at its point of contact with the present system. In estimating the inconvenience of this break it would be incorrect to measure it by that which formerly occurred at Gloucester. An incident that was annoying and costly in the journey between Bristol and Birmingham would become insignificant between London and Kurrachee; for it is certain that every passenger would leave the through train for the full time allowed at each stopping place; and it would be a matter of indifference whether he returned to the same carriage or to another which had been put in its stead. In their pamphlet the promoters speak of "passengers and mails" only; and in the face of water carriage, there would probably be little through goods traffic of a heavy description. But a break of gauge is an evil in a comparatively short journey, chiefly on account of the necessity for shifting heavy goods and live stock; and if this necessity did not exist the evil would be reduced to very small proportions. Another element of the case is that the rapid change of climate would probably render necessary a change in the construction of the carriages used over different parts of the line; and, if this were so, the objections to a break of gauge would be practically at an end.

It is quite obvious, however, that the letter of Messrs. Low and Thomas can only be regarded as a sort of pilot balloon, and that very much preliminary work must be accomplished before any question of detail will be ripe for discussion. In the meanwhile the pamphlet will do good by calling attention to the subject, and by familiarising the public mind with an idea which, at first sight, seems almost too stupendous to be realised.

THE "WOOLWICH INFANT."

The 35-ton gun, or "Woolwich Infant," has lately been undergoing a series of experimental trials, for the purpose of ascertaining the highest which can be attained by projectiles fired from it with various-sized cartridges, together with the maximum quantity of powder which can be instantaneously converted into powder gas within its capacious charge chamber when the cartridge is ignited. Our readers will remember that early in the present year a number of preliminary experiments were tried with this gun, at which time it was only bored out to a calibre of 11·6in. Since then it has been returned to the Royal Gun Factories, again passed through the boring mills, and the diameter of its bore increased to 12in., such being the size of the projectile that it was originally destined to throw. Some flat-headed solid shot of similar dimensions have likewise been manufactured, their weight being, as in those prepared for the former experiments, 700lb. The present experimental trials—which are the first that the monster gun has been subjected to since its alteration in calibre—were held under the able superintendence of Colonel Younghusband, R.A., President of the Committee on Explosives, but were actually conducted by Captain Noble, R.A., secretary to the same. Their results were highly satisfactory, and proved beyond doubt that the 35-ton gun can do all that was expected from it, so far as regards the nature of the tests hitherto adopted. The first six experiments were made with charges containing 110lb. of pebble powder each, alternately of Waltham Abbey large grain and Belgian small grain. The first, third, and fifth shots with the Waltham Abbey powder gave an initial velocity of 1,274, 1,269, and 1,272 feet in one second respectively. The second, fourth, and sixth shots with the Belgian powder gave 1,301, 1,302 and 1,300 feet in one second respectively. From this it might be inferred that the Belgian powder is superior to the English. But such is not the case. The Belgian powder although giving a trifle more initial velocity than the Waltham Abbey powder, exerts a force of impact so far greater upon the inner surface of the charge chamber, that this disadvantage more than counterbalances the advantage gained in the other respect. The second series of experiments was made with six charges—alternately Waltham Abbey and Belgian, as before—containing 115lb. of powder each, with the following results :—The first, third, and fifth shots with the Waltham Abbey powder gave an initial velocity of 1,300, 1,289, and 1,295ft. in one second respectively; the second, fourth, and sixth shots with the Belgian powder, 1,340, 1,355, and 1,350ft. in the same respective times. In all these experiments the whole of the powder was ignited, in consequence, probably, of the cartridge having been reduced in longitudinal dimensions, thus bringing its contents into a more compact mass. The force of impact exerted upon the inner surface of the charge chamber, as shown by three pressure gauges, one inserted in a copper cup at the extremity of the chamber, another in the vent-hole, and the third in the centre of the projectile behind, was considerably less than during the previous experiments the highest pressure registered with the Belgian powder being no more than 30-tons on the square inch, that with the Waltham Abbey being less than 25, while the enormous pressure of 49-tons per square inch was registered with the Belgian powder under similar circumstances in the spring. The pressure gauge employed for registering the force of impact deserves especial notice for the ingenuity of its construction. A small piece of copper is contained within a metal cylinder rather wider than itself. A piston closely fitting the cylinder rests upon the piece of copper; when the metal cylinder, or pressure gauge, is applied to the inner surface of the charge chamber, the expansive force of the powder gas presses upon the piston, and drives it down upon the piece of copper, which is crushed. The extent to which the copper is crushed gives the force of the blow. The recoil of the gun during some of these experiments was tremendous in its effects. On several occasions the whole of the huge mass, weighing about 40-tons, flew backwards to the summit of the inclined plane or bed, and derived such a momentum from its elevated situated that it ran down again to the platform and put itself in position. The wind, too, at the muzzle when the charges were fired was like a hurricane in it violence. Planks three inches thick were tossed up high in the air as though they had been pieces of paper, and one was blown to pieces. The committee are also conducting experiments with the 10in.-gun, muzzle-loader, fitted with crusher gauges in all parts for the purpose of ascertaining the pressure. This gun was fired with the enormous charge of 700lb. of powder and a cylinder weighing 800lb., the consequences being rather more than were anticipated, as the gun was dismounted from its platform and the patent buffers considerably damaged. The gun has, however, to undergo still further trials, for it has to be fired with four charges of 1,000lb. of powder each, and four of 1,200lb. each, the projectiles of the heaviest weight being over six feet in length.

THE ST. GOTHARD RAILWAY.

The following is the Convention signed on the 10th ult. by Privy Councillor Dr. A. Escher, in reference to the raising of the private capital which will be further required for the completion of the works in connection with the St. Gothard Railway :—

1. For the purpose of carrying out the works in connection with the St. Gothard Railway, the direction of the Discount Company at Berlin, Mr. S. Bleichröder at Berlin, Messrs. M. A. von Rothschild and Sons at Frankfort-on-the-main, the Bank of Commerce and Industry at Darmstadt, A. Schaffhausen's Banking Association at Cologne, and Messrs. S. Oppenheim, jun., and Co., at Cologne, undertake the formation of an international association, to consist of a group of Swiss railway companies, banking establishments and bankers, and of Italian and German banking establishments and bankers.

2. The German group shall take to themselves one-third part of the entire business, the Swiss and Italian groups participating each in an equal degree. The latter must have given in their adhesions to this convention by the 24th ult. at the latest. The German members are also bound to undertake to furnish that amount which might not be undertaken by the other groups.

3. In all engagements to be entered into by the Association the joint liability of the parties interested shall be excluded.

4. The Association shall form the St. Gothard Railway Company on the basis of the statutes to be hereafter agreed upon, and it is left to the option of the St. Gothard combination to supplement the statutes to be hereafter agreed upon by adding further regulations in reference to the organisation of the Board of Directors, the Council of Administration, as well as the decision as to the locality of the head office of the company. These additions, like the statutes, are to be subject to the approval of the Swiss Federal Council. The Association, however, in case it should

think fit, reserves to itself the right to make known its opinions on this question to the St. Gothard Railway Company and the Swiss Federal Conncil, especially as regards the organisation of the Council of Administration and the Board of Directors.

5. The Association agrees to take the shares to the amonnt of 34,000,000f., which are to be issued in conformity with the statutes of the company at the rate of 95 per cent., less 3 per cent. commission. The payment of the calls is to be made at a rate not exceeding 20 per cent. The first instalment of 20 per cent. is to be paid immediately upon the conclnsion of the State contract. Upon the demand of the Association the St. Gothard Railway Company will permit the payment of the second call of 20 per cent. to be effected at an earlier period than that provided for by the statutes. By paying the second call the liabilities of the Association with regard to the taking over of the shares is fulfilled.

6. By virtue of its statutes the St. Gothard Railway Company shall issne preferential bonds to the nominal value of 68,000,000f., bearing interest at the rate of 5 per cent. per annum, to be paid half-yearly; the period of redemption being fixed at 18 years, commencing at the date of issne. The St. Gothard Railway Company shall, however, be entitled to redeem the capital after the lapse of 12 years. These bonds are to be divided into four series, enjoying equal priority. The first series to consist of 12 millions, the second of 18 millions, the third of 18 millions, and the fourth of 20 millions. These series may bear different dates of issue.

7. The Association agrees to take these bonds firm at the rate of 97 per cent., less 2 per cent commission, and is bound to take the first series at the time when the payment of the first call on the shares is made, while the other series shall be taken at a period to be fixed upon by the St. Gothard Railway Company.

8. The Association is bound to deposit cantion money as a guarantee for the due taking of the bonds, which shall be 20 per cent. of the amount of those bonds that have not been taken, and this guarantee is to be paid in bonds of the company. During the time the caution money is deposited the parties interested hereby engage, for the due fulfilment of the dnties connected with the obligations entered into, to choose their legal domicile within the Swiss territory. All notices and summonses for the same may be delivered at the Chancery-office of the Swiss Confederation.

9. The company accords to the Association one-third part of the amounts economised in the construction of the great tunnel, exclusive of the stone-work, bnt inclusive of the double upper works, in reference to the preliminary estimate of 3,733f. per metre.

10. The company to be formed by the Association shall pay to the St. Gothard Company the cash outlay incurred during the year in advancing the works to that stage in which they are at this moment.

11. The St. Gothard Company transfers to the company to be formed by the Association all concessions which it may possess for the construction of the St. Gothard railway system, as well as all rights and obligations accruing therefrom.

12. For the due fulfilment of the conditions stipulated in this agreement, the Association shall deposit with the Swiss Federal Council caution-money to the amount of 10,000,000f., in current coin, or in securities at the current exchange, to be declared a legal tender by the Swiss Federal Council. This caution money is to be paid immediately upon the expiration of the term accorded to the Swiss and Italian capitalists for joining the Association. The caution-money is to be retnrned to its owners as soon as the same have paid the first 40 per cent. on the capital in shares, and the first 12,000,000f. on the capital in bonds. During the time of the caution-money being deposited, the firms which form the combination shall choose, for the due fulfilment of the stipulations entered into by the present treaty, their jndicial domicile within the territory of the Swiss Confederation. Any notices and citations for the same may be legally delivered at the Chancery-office of the Swiss Confederation.

13. This agreement shall come into operation so soon as the State Convention, according to which the St. Gothard Railway Company shall receive a subsidy of 85 millions of francs, has been finally concluded. If this shonld not yet have taken place, on the 31st of December, 1871, the Association shall be entitled to give notice of its withdrawal from the present treaty, and to demand that the caution-money should be returned.

14. The ratification of the treaty is left open to the St. Gothard Railway Company up to the 24th nlt., inclusive. The Association is at liberty to withdraw from the present agreement if the ratification has not taken place at the period stated.

AMERICAN PATENT LEGISLATION.

The following is an extract from the address delivered, at a quarterly meeting of London Patent Solicitors, on the 4th ult., by George Haseltine, M.A., L.L.B., the Chairman :—

"American legislation on patents for inventions is based on the first article of the Constitution. The eighth section declares that Congress shall have power to promote the progress of science and the useful arts by securing authors and inventors the exclusive right to their respective writings and discoveries. The Colonial and State authorities had exercised to a limited extent the prerogative of awarding inventors exclusive privileges, but the Confederation which preceded the National Union was not empowered to grant protection to the prodnctions of inventive or literary genius. The Constitution has not prohibited the States' granting patents, but it was the evident intention of its framers to confine this class of legislation to Congress.—an intention respected by local legislators who have enacted no general patent laws, and inventors have been so well content with the liberal character and efficient administration of the national system, that they have rarely sought other protection or additional rewards. The legislature of the Empire State in 1798 passed a special act, granting Robert R. Livingston the exclusive right of constrncting and navigating every species of boats, propelled by the force of fire or steam, within its jurisdiction, for the term of twenty years, provided he shonld, before the expiration of twelve months, construct a boat of twenty tons capacity, with a mean speed upon the Hudson River of four miles an hour. The patentee forfeited the grant, which was renewed to him and his associate Robert Fnlton in 1803, and again five years later for terms of twenty years. This grant possesses a scientific and historical as well as legal interest. It affords an eloquent illustration of the infancy and progress of steam navigation, with which Fulton was so intimately identified—a progress that has attained a mean speed of twenty miles an hour upon the Hudson, and transformed a boat of twenty tons into a steam-ship of more thousands. This fire-steam navigation proved a commercial success, which excited the envy of losing competitors, whose infringement necessitated a chancery suit—not an uncommon result in later times—that at once impoverished the plaintiffs and established the concurrent but subordinate jurisdiction of the States in patent legislation. The Court of Errors, of which Chancellor Kent, the American Blackstone, was then a justice, decided unanimously in favour of the local grant. The judges adopted, without reserve, the doctrine of State Sovereignty, which now finds little favour with American legislators, though the amended Constitution expressly declares that the powers not delegated to the nation are reserved to the States or to the people. The first Congress, recognising the justice and realising the policy of an efficient patent system, passed an act to promote the progress of the useful arts, which was superseded three years later by a similar statute, and a repealing act was passed in 1836, which in turn was snperseded by the general statute of 1870. Several minor acts intervened, and notably the one increasing the original term of a patent to seventeen years, and eqnalising the fees to native and foreign inventors. Throngh all these changes the law-makers have never questioned the equitable rights of invention, or the wisdom of satisfying these rights by exclnsive privileges for a term of years. The Colonies and States, imitating the practice of the Mother Country, had more often granted patent privileges to importers than to inventors.—a pernicious practice, that has found no recognition in the national legislation. Though the Common Law, that regards alike the importer and inventor, was the prevailing law of the States—a fact well known to the authors of the Constitution—and, subordinate to the statutes, was formally adopted by Congress, the American courts have never held that first importers are true inventors. The right to grant patents of importation is still vested in the States as the source of political power. The liberal legislation of Congress, which, recognising the universal brotherhood of genius, offers princely rewards to inventors without distinction and virtually without price, has made America the home of inventions—the paradise of patentees. Sixty thousand original patents have been granted in sixty months, and half as many applications rejected on strict investigation of novelty—still this rate of issue continues, infusing new life into every branch of industry. The money-valne of these patents is counted by millions—their industrial value exceeds the national indebtedness. Modern inventions constitute a vast wealth of the Union, whose marvellous progress is less attributable to the richness of its mountains or the fertility of its plains, than to the restless genius of the people. The demand for new inventions is insatiable, enterprises are impatient, and the State that incited the ingenuity of a Fulton to design a twenty-ton steam-boat for the Hudson River, has recently offered a prize of £20,000 to the pioneers of steam navigation on the Erie Canal. Inventors are honoured as public benefactors, and the nation has erected to its hundred thousand patentees—the leaders of its grand army of industrial progress—a marble temple of art, the noblest structure ever dedicated to the genius of invention."

PORTABLE GAS GENERATOR.

This machine has certainly the merit of simplicity, and we are told works well even in cold weather, without the aid of heat, consuming gasoline of the density of 85°, without condensation. In warm weather much heavier fluid may be used. The machine consists essentially of two parts, an air compressor or forcing apparatus, and an apparatus for charging the air with the hydrocarbon vapour. A barrel or case, A. Fig. 1, is divided by a diaphragm, B, Fig. 2, into two compartments or chambers, which communicate with each other by means of the pipe, C. The fluid is put into the case through a supply cock, not shown, and rises to a common level in both compartments. In operation this fluid circulates more or less through the pipe, C, between the compartment containing the carburising apparatus to the chamber containing the air-forcing apparatus. The denser portions of the fluid are, by revolving drums, D,E, Fig. 2, kept constantly stirred up, mingled and vaporised with the lighter portions. The drum, lettered E, is the air-forcing drum. It consists of a set of buckets extending spirally as shown in Fig. 3, from the hollow shaft, F, Fig. 2. It rotates in the reverse direction from that of an overshot water wheel, and in so doing carries the air which enters the chamber through the pipe, G, under the surface of the liquid. Thence the air passes through the perforations in the hollow shaft and through the shaft into the carburising chamber, passing out of perforations in the shaft into the buckets of the carburising drum. This drum is similar in construction to the other, but it is smaller and has a less number of buckets. In the hollow of these buckets is placed felt, wool, or other capillary and absorbent material, which is kept constantly saturated in passing through the hydrocarbon liquid, and the air in passing out through this material becomes charged with illuminating vapour, or gas. In this state it is passed through the pipe, H, into the chamber, 1, whence it is passed to the service. The chamber, 1, acts as a storage for the gas, so that enough will be kept therein to supply the burners when winding up the machine. The carburising drum has its buckets placed in a reverse position on the shaft to those of the forcing drum or compressor. The power used to drive the machine is a weight and cord, acting through a shaft, pulleys, and belt. The weight is wound up in the usual manner.

Fig. 1.

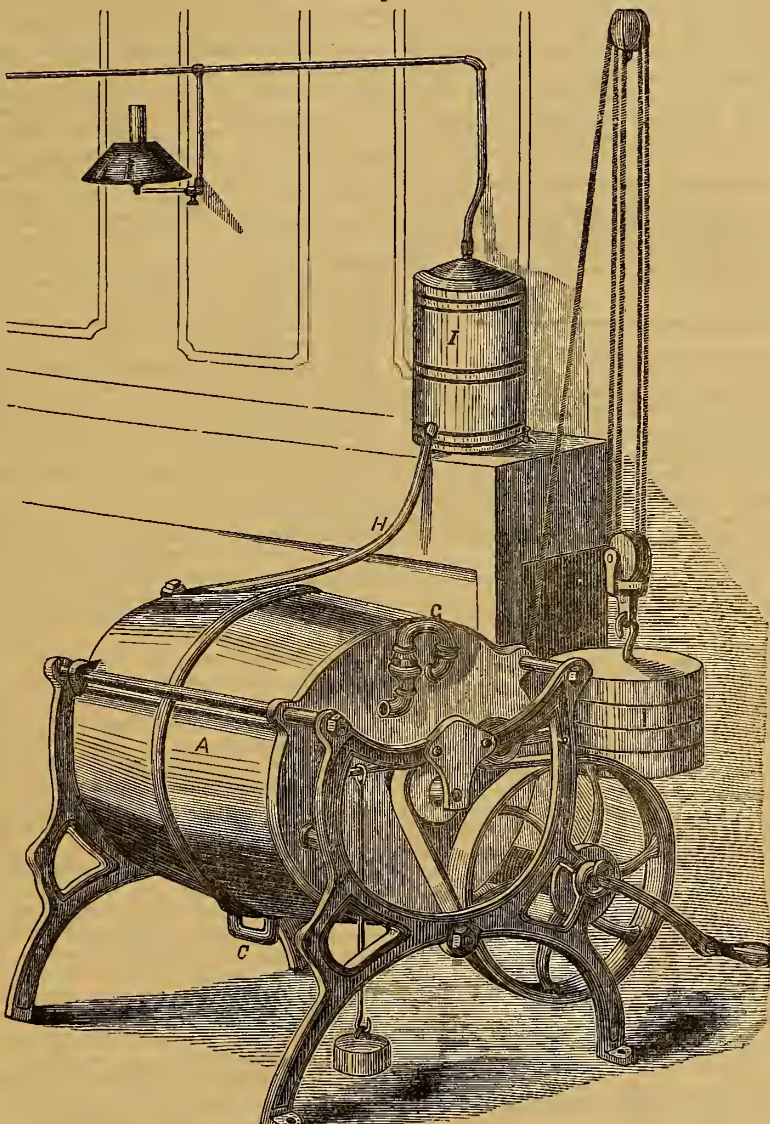
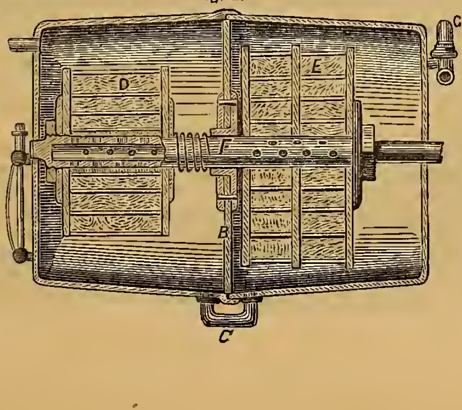


Fig. 3.

Fig. 2.



THE DETROIT RIVER TUNNEL.

This work upon the river tunnel is to be commenced at once. Mr. Joy has returned from the East, and will see to it that operations are begun at the earliest practicable moment. All the money required has been secured, organisations have been effected on both sides of the river, which in due time will be consolidated; the City Council has adopted, and the Mayor has approved, the ordinance giving the right of way through and under the streets; and all that now remains is for the engineer to prepare the necessary working plans, set the machinery in place, and go to work. Mr. Cheesebrough, the engineer who constructed the lake tunnel at Chicago, and who made the surveys of the river bed and approaches, and prepared the plan of the proposed tunnel here, will have charge of the work. The plan of the tunnel contemplates really a series of three cylindrical tunnels. Two of these will be for railroad purposes, each being 18½ft. interior diameter. They will be parallel, and 50ft. apart. This plan is deemed preferable to a single tunnel with double tracks, both on account of less liability of accident to trains and delay from obstructions, and on account of the strength and economy of the structure. The third tunnel will only run under the river, and will be below and midway between the other two. It is designed for drainage purposes only, and will have an interior diameter of five feet. The third tunnel will be constructed first, in order to fully develop the character of the soil which is penetrated, and to drain the other two tunnels as the work progresses. It is expected that the building of the lower tunnel will fully determine the feasibility of the whole project; and this will therefore be completed before work is undertaken on the railroad tunnel proper. If difficulties are met with anywhere, of course they will be underneath the bed of the river, and the drainage tunnel will be likely to encounter them. Their nature, and the possibility of overcoming them if they are met, can then be determined, before any great expense is incurred or property of the city is damaged by excavating in and underneath the streets.

Work will be first commenced on the grounds of the Detroit and Milwaukee Railroad Company, near the foot of St. Antoine-street. Here a shaft, ten feet in diameter, will be sunk to the required depth, and excavation under the bed of the river will proceed from that point. As the

excavating proceeds, a shell of brick masonry will be constructed in a permanent manner. By the time the middle of the river is reached, if the project still appears feasible, operations of a similar character will be commenced on the other side of the river, and the work will proceed from both directions. The building of this experimental and drainage tunnel, it is expected, will not consume more than two or three months; so that we shall soon know whether or not the proposed railroad tunnel under the river is possible. If the successful completion of the first tunnel shall prove that it is so, work upon the others will be immediately begun and proceeded with, with all possible dispatch. The engineer estimates that a year and a half or two years will be required to complete the work, allowing time for unlooked for delays, and proceeding cautiously and slowly under the bed of the river, where the water is deepest and there is danger. Of course, much depends upon the results attained in the experimental tunnel. If it shall appear that the larger tunnels can unquestionably be built, and without danger or delay, the work will be pushed with all possible dispatch, and probably completed within a year.

The company which has undertaken this project only require to know what is feasible in order to have it completed and in practical operation at the earliest possible moment. The entire length of the tunnel, not including the approaches, will be about two miles, and its estimated cost nearly 3,000,000 dols. When completed, it will be used by all the railroads entering the city.—*Detroit Post.*

PAPER-MAKING IN JAPAN.

The art of paper-making in the country of the Mikado forms the subject of a very interesting Parliamentary document just issued, comprising reports from three of her Majesty's consuls in Japan. Mr. Lowder's report, addressed to Sir H. Parkes, from Kanagawa, was accompanied by numerous coloured illustrations, the work of native artists, and costing only four dollars. These illustrations now accompany the report in the form of engravings, and are highly interesting, being singularly bold and graphic, conveying a very clear idea of the processes referred to.

According to Mr. Lowder, the manufacture of paper from the paper-mulberry (*Broufsonetia papyrifera*) was introduced into Japan about A.D. 610, being mainly brought about by the skill and enterprise of Shôtoku Taishi, a son of the reigning Mikado, who improved on what he had previously learned from Donchô, a priest from the Corea. This Donchô is said to have been a clever man, learned in the Chinese classics, and a skilful artist. But his paper was not all that could be desired. It did not take ink well, and it tore very easily. Taishi had recourse to the paper mulberry, and caused it to be extensively planted all over the country, taking measures at the same time to have the mode of manufacture largely promulgated among the people. From the year 280, paper had been imported into Japan from the Corea, but soon after 610, thanks, to the ingenuity of Taishi, the Japanese learned to make their own paper, and even made it of better quality than that of Corea. The art, as practised in the present day, is very rude in its appliances, but is very satisfactory in its results. The mulberry stalks, cut into lengths of three feet or rather less, are steamed, and the skin thus softened is afterwards stripped off by hand. The skins thus peeled off are hung up to dry, a process which occupies from one to three days. They are tied up in bundles, and exposed to the action of running water for twelve hours, or perhaps twenty-four. After this washing, the outer dark skin is stripped off from the inner fibre by means of a knife, the tool being held stationary with the right hand pressing on the material, which lies on a straw padding. The operator then draws the material towards him with the left hand, and as the stuff passes under the edge of the knife the outer fibre is stripped off. The dark outside skin is used for making inferior kinds of paper. After being thoroughly washed in running water, which causes it to open out flat, it is boiled. It is then allowed to rot, and is well beaten, after which paper is made of it, by admixture with the "tororo." In years when the paper-mulberry is scarce, this kind of paper is sometimes made of the common mulberry. The mode of manufacture is the same, and the leaves are occasionally made use of for the purpose.

Reverting to the treatment of the inner fibre, we observe that this is parcelled into lots of about 32lbs. avoirdupois each. It usually takes three days to make this into paper, but adepts can accomplish its manufacture in two. These parcels are taken to the river and thoroughly washed, after which they are steeped in buckets of water. The water is then run off, and heavy stones are placed upon the fibre to squeeze out the remaining liquid. The parcels are next boiled, so as to get rid of all sticky and glutinous matter, and the fibre is then called "sosori." Great care has to to be taken that the boiling goes on evenly, and sometimes the boiling has to be assisted by throwing in wax-ash or common lime; but the admixture of either of these will slightly affect the colour of the paper. The boiling, moreover, is not carried on by means of common water, but by the use of water in which the ashes of burnt buckwheat husks have been infused. After this boiling, the sosori undergoes a second washing, in order that the residue of the ash infusion may be thoroughly expelled. For this purpose it is placed in a basket, through which running water is allowed to percolate, after which the basket is lifted up, and the water runs off. The night before the paper is made the sosori is again washed, and the next morning it is pounded "for about as long a time as it takes to boil the rice for breakfast." When paper is made in the winter a little "tororo" is mixed with the sosori before pounding, but in spring rice-paste is used. The tororo is a plant, having a root about the same size as that of the common dock. The sprouts and skin of the root are scraped off, and the root is then beaten. When required for use, the "tororo" roots are boiled into a tolerably thin paste, and strained through a fine hair-sieve into a tub.

In making the paper called "hanshi," the sosori is first formed into a large ball, from which large lumps are broken off as required. These lumps are cast into what is called the "boat," and thoroughly mixed with well-strained tororo paste. The necessary pulpy mass is thus formed. In making "hanshi," the boat containing the pulpy material has a length of six feet and a breadth of three. A sort of tray or frame, of the requisite size, has a false bottom of plaited bamboo. This tray is dipped into the pulp, or the pulp may be poured into it. An inner frame is then fitted so as to press down on the false bottom and keep it tightly in its place. A peculiar and dexterous jerk is then given to the apparatus, which has the effect of "setting" the paper. The frame is then placed in a leaning position against an upright rest in the boat, to allow the water to run off, while another frame is prepared. By the time a second frame is ready, the first may be removed, and the entire manipulation is such as can be performed very quickly by experts in the manufacture. Paper made in the winter with "tororo" has the advantage over that made in the spring with rice paste, that it is not likely to become worm-eaten.

In order to dry the paper, the sheet is removed from the frame with a piece of bamboo, the thicker end of the paper being dexterously curled round the stick. By means of a brush the paper is laid on the drying board, face downward. Five sheets are placed on each side of the board, which is six feet long, and each manipulator requires 40 drying-boards. In fine weather the paper dries quickly; in wet weather it is sometimes dried by the heat of a fire. Cutting is effected by a knife, applied to parcels of 100 sheets. Packing into bundles for the market follows.

Mr. Annesley, writing from Nagasaki, describes the mode of making paper from the bark of the "kaji" tree, and says—"There are no reasons why the 'kaji' tree should not flourish in England, more especially if planted in a damp soil; and when it is considered that paper could no doubt be manufactured from this bark at a cheaper rate than it could be made from rags, added to the considerable strength it can attain, and the various useful purposes to which it can be applied, the cultivation of the 'kaji' shrub in England is well worthy of a trial." The writer adds—"Some inquiry after this bark has been made by some paper manufacturers from merchants at this port, and samples have been sent to England, where its value will no doubt be appreciated and turned to account." The many forms which paper takes in Japan seem to suggest that we are far behind in the development of this industry. The Japanese will make paper "warranted to wash." They also manufacture oil-paper for rain-coats and other purposes. Some of the common paper is made so tough that it can be torn only with difficulty. Paper is made to have the weight and hardness of heavy wood, or the lightness and elegance of net. Paper hats are made in imitation of straw, the paper being twisted, plaited, shaped, and varnished. Leather is also imitated, and these imitations have excellent qualities to recommend them. Coats, shoes, umbrellas, pocket-handkerchiefs, and numberless other articles, are made from paper. As for the raw material, we are told that the Japanese are acquainted with the method of making paper from rags, but never adopt it, preferring to make their paper from the bark of trees. If the kaji tree can be successfully grown in England, our own paper-makers might find it a very useful source for a portion of their raw material. The Japanese seem to luxuriate in an abundance of "sosori;" but in this country the paper-making industry is hemmed in by a comparatively narrow circle. This news comes from Japan very opportunely, and the document before us states that sundry samples of the material have been sent to the South Kensington Museum. The subject is not merely curious, but important. Sir H. Parkes regrets that the information afforded in the consular reports is not more complete, but says:—"It has not been found easy to obtain information from Japanese informants engaged in the trade relative to the production of the raw material or the mode of manipulation." The manufacture appears to be carried on in the interior provinces, and no opportunity of observing the process has been met with at Yeddo.

IRON AND STEEL INSTITUTE.

THE HEIGHT OF BLAST FURNACES.

By Mr. T. W. Plum, Shifnal, Salop.

The author stated that this paper had in a certain degree grown out of the discussion on the Ferrie furnace at the last meeting in London. In the course of that discussion it was contended that the very large proportion of the saving of fuel was due to the increased height of the furnace, and that no additional advantage was gained by the cross walls. It was, however, at the same time, suggested that these latter were calculated to answer an important purpose, in relieving the weight that, in an open furnace, is imposed upon the materials, and this high furnace could be used in districts where the fuel is to tender to bear a considerably increased weight. From certain facts which Mr. Plum gave in detail, he concluded that the novel and peculiar construction of the Ferrie furnace has more to recommend it than at first sight appears, and that the advantages it promises to realise are well worthy of close investigation by the institute. Passing on to consider the example of the Cleveland Ironmasters in increasing the height of the blast furnace he pointed out that this plan has not been very extensively followed out in other localities, and it is still a question in the minds of some gentlemen of great experience, whether so much of the saving of fuel attributed, is really due to the greater height. He had information of South Staffordshire furnaces working with a yield as low as 28 cwt. of coal to the ton of iron made, though he informed the meeting that this statement should be accepted with reserve, as the Staffordshire method of reckoning weight is a very lax one. The author next went on to detail certain improvements that seemed to have added so much to the prosperity of the northern ironworks, and which he had endeavoured to engraft upon an old and dilapidated plant in Shropshire, but the different arrangements in form and condition of the old ironworks, and the diversity in the nature of the materials made it necessary to proceed with much care in the reconstructing or in adapting the old furnaces to new modes of working. The Old Park Company's furnaces, four in number, were 45ft. high and 14ft. 6in. at the bosh. A portion of the gas was taken from two of these by Darby bells, and utilised for raising steam only. In 1869 it was decided to erect one new furnace, in the place of an old one, to be of the same height, but of more modern construction, viz., cased with iron plates upon twelve iron standards, 6ft. 6in., close hearth, six tuyeres equally divided, with provision for a portion of the gas to be taken off by a culvert round the neck of the furnace. The size at bosh was 14ft. 9in. While in progress it was determined to make a trial of an increased height of 15ft., making the furnace 60ft. high, and it was so finished and got to work, but at present the results obtained from it have not been complete, in consequence of both heat and pillar of blast not having been as yet so much nor so uniform as required for testing its capabilities; but comparing its work with the other furnaces, so far as it has been practicable to do, the best result has been a yield of about 10 cwt. of coal per ton of iron less than the best on record in the old furnaces. The quality of the metal has been better, and alway greyer than indicated by the cinder, usually the reverse of the old furnaces. The favourable comparison obtained from the higher furnace led to the idea of raising one of the old ones to the same height (while working) by putting on an outside casing to the tunnel head, leaving the gas to be taken off about 20ft. from the top. At first there was no provision for utilising the gas, and the furnace worked extremely hot at the top, and the yield was excessive. It was somewhat improved after the gas was partially withdrawn, but until recently this furnace has not been fairly comparable with the others. From the experience thus gained the author arrived at the following conclusions:—1. That an improved yield has been decidedly obtained from the increased height of the furnace described. 2. That to the extent of 60ft. it may be safe to construct furnaces in districts having tender cokes to smelt with, but certainly not more, unless upon the Ferrie system, if found to answer the purpose of adequately relieving the materials from undue pressure, as well as of improving the yield, for which the experience in Scotland will doubtless be resorted to for guidance.

HOT BLAST STOVES.

By Mr. Thomas Whitwell.

The writer commenced by stating that the present paper was a kind of supplement to that read before the Institute some time ago, wherein a description of the stoves as put up at the Consett Iron Works was given. The results submitted in this article are those of the continued working of the apparatus, extending, the one over a course of 2½, and the other over 1½ years. In the previous communication, it had been stated that the stoves were applied to a furnace 55ft. in height, 20ft. bosh, 15ft. 6in. diameter below charging plate, and 8ft. hearth; that the average heat, as proved by Messrs. Charles Cochrane and E. A. Cowper, was upwards of 1,400° at the tuyeres; that the mineral charged consisted of one-third hematite, and two-thirds Cleveland, a mixture containing 48 per cent. of metallic iron; that the consumption of coke per ton of iron during the first year was 17 cwt. 3 qrs. (weekly make per furnace, 380 tons); that the quality was grey forge, and that the proportion of white iron was only 2 per cent. over the year. The author then referred to a series of papers communicated to the Institute by Mr. I. Lowthian Bell, one of which treated of the results of the working of the furnaces at Consett, wherein he remarked that the increased heat supplied in the blast had been followed by an increased consumption of coke, and the analysis of the gases at the top of the furnace showing more carbonic acid, and less carbonic oxide. Mr. Bell deduced therefrom that the result must have been produced by the heat of the blast only. That gentleman suggested to the company that the heats should be reduced.

Mr. Whitwell next referred to the relative sections of the blast furnace, working with the fire-brick stoves. No. 4 furnace was blown in during February, 1869, and the averages commenced six weeks after—viz., on April 10th. The pressure of blast at first was 2¾lb., and during the year was increased to 3lb. per inch, when the temperature was about 1,400°, and the average consumption 17 cwt. 3 qrs. per ton of iron produced, the total make being 373 tons per week. During the latter half year the make rose to 401 tons per week, and the coke fell to 17 cwt. 2 qrs., the quality of iron being 84 per cent., No. 4 grey forge. During the next three months there was a little hanging, and some forge slag being put into this the average make per week gave 383 tons with 18 cwt. 0 qrs. 3 lb. coke used per ton of iron. The blowing power was then improved, a higher pressure of blast tried, and the furnace was put on the old burden of one-third hematite and two-thirds Cleveland. There was then noticed an increase in production. When, however, the pressure was raised 69 lb., per square inch, or 40 per cent. the production showed a corresponding increase, but the stoves being already worked to their full power were not able to develop the same temperature, and hence when the pressure of blast was raised to 4 lb. at the beginning of the present year, the production of pig increased 45 per cent., but the consumption of coke with the decrease of temperature to 1,200° had risen to 19 cwt. 2 qrs., which increase represents a money value of nearly 1s. 3d. per ton of iron based on the price of coke in the Middlesbrough district. The out-put is now 510 tons per week, being 91 per cent. grey, 9 per cent. mottled, and a trace of white pig. The largest quantity turned out in one week was 587 tons.

The writer next referred to No. 5 furnace, which is different from the one above mentioned in so far as though the same height it is 22ft. 6in. diameter at the bosh, and 20ft. 6in. below the charging plate. Four fire-brick stoves, with an increase of 17 per cent. in heating surface were applied, and on first blowing in, the heats were 50 per cent. higher than in the case of No. 4, and more regular. About 1½ cwt. more coke was used when the blast was at 1400° and about 25 per cent. of white pig was made. This furnace has made all qualities of pig with a mixture of one-third hematite and two-thirds of Cleveland from No. 1 to white, but the production of white without any visible cause has continued. With the heat and pressure of the blast perfectly regular the author thought that the production of pig iron should have been regular also, but such not being the case, he considered this question very minutely. He had traced the irregularity of yield to the charging, but other iron masters had considered there was no fault to be found with that or the shape of the furnace. The make average 393 tons per week for the first three months with coke 19 cwt. 2 qrs. 8 lb. per ton. Early in the current year the temperature was reduced to 1250° as advised by Mr. I. Lowthian Bell, so as to compare with No. 4 on equal temperatures, but the coke went up to 21 cwt. 2 qrs., being an increase of 2 cwt. for 200° of temperature. The irregularity continued, and the nozzles were enlarged to 84 square inches of area, but without remedying the defect; in fact the production is 60 tons per week less than No. 4, and that at an increase of 2 cwt. of coke per ton of iron turned out. The Consett Company are about to reduce the diameter of the upper part to that of No. 4, as the present dimensions, though they may suit an 80ft. furnace, will not do for a 55ft. one, with the mixture named. The writer thinks that in the case of No. 5 the coke and larger pieces of the charge roll to the centre, the small mine and ore remaining near the periphery of the furnace, the blast forces its way up the line of least resistance, viz., the centre. The Consett Company decided to apply the stove to two new blast furnaces, the size adopted being the mean between 4 and 5, viz., 21ft. bosh, angle 72°, size under bell 18ft. 6in. diameter of bell 11ft., with a view of arriving at the maximum economy by experiment. One of these furnaces has been in blast about two months, and so far the consumption of coke promises to be the mean between the quantity used in 4 and 5.

The author attribntes the successful working of No. 4 to the action of the brickwork in the stoves, which form in actual practice large reservoirs of caloric at a temperature of 1400°, this heat being given off when a stand takes place at tapping time, a "tuyering" or a "scaffold," when in all cast iron plant, no gas being produced, the stoves are being eooled down, an effect prejudical to the working of the furnace. The fire brick stoves being always bright red, throw the blast hot into the furnace when it is most needed. These stoves differ from the Siemens system, where all the air is admitted at one point and where a heat for a short time of 1800° has been obtained, in so far as the heated air is admitted among the gas at several points. In conolusion the writer gave the following in his deductions from the above results: 1. That the increase in production in the furnace N. 4 at Consett is directly in proportion to the iucrease in the amonnt of blast thrown into the furnace and not consequent on the reduction of temperature. 2. That other things such as the action of materials in the charging and form of furnace being eqnal, regularity of qnality in the iron is in no degree incompatible with a high degree of temperature in the blast. 3. That in the two furnaces at Consett, although there is a great difference in the internal form and capacity, yet no reduction of temperature of the blast has bcen attended with economy, but that in both cases a reduction of 200° in its temperatnre has been accompanied by an increase of upwards of 2 cwt. in the consumption of coke per ton of pig iron produced.

THE BRITISH ASSOCIATION.

(SECTION B.)

ON THE EXISTENCE OF SULPHUR DICHLORIDE.

By JOHN DALZIEL and T. E. THORPE.

When dry chlorine in excess is passed through molten sulphur, a dark red fuming liquid slowly distils over. This on renewed distillation eommences to boil at abont 50° or 60°, and the thermometer slowly rises to 136° or 137°, at which point it remains stationary, and orange-yellow disulphide, Cl_2S_2, passes over. The fraction boiling below 136° frequently amounts to threc-fourths of the original quantity of liquid; on again submitting it to distillation, the same order of things is repeated, and but a comparitively small portion distils over 136°. At each distillation the liquid becomes lighter in colour, until at length, by long-continued boiling, it assumes the bright yellow tint of the disulphide, and boils constantly at 136° to 137°. This behaviour would seem to indicate the existence of some compound of chlorine and sulphur which slowly nndergoes decomposition on distillation, nltimately forming the disulphide, and the observations of Dumas and Soubeiran, and of Marchand, Davy, and Rose, point to a body richer in chlorine than the disulphide, and their analyses leads to the formula SCl_2. On the other hand Carius denies the existence of sulphnr dichloride in the dark red liqnid obtained by heating snlphur in chlorine, and asserts that the compound analysed by Dnmas and others was a mixture in atomic proportions of the disulphide with a tetrachloride of sulphur hitherto unisolated, $Cl_2 S_2 + SCl_4 = 3Cl_2S$. According to Carius, the amount of chlorine contained in the liquid over and above that reqnired by the formula S_2Cl_2 is altogether dependent on the temperature; but the faot of the protracted distillation required to break up the product into a liqnid boiliug constantly at 136° to 137° implies, however, that the excess of chlorine is held by some other force than that of mere solution; at the same time we are not altogether without facts more directly indicating the existence of the diehloride. Rose has obtained a compound of this body with the terchloride of arsenic, $_2AsCl_3Cl_2S$, and according to Guthrie it yields with the olefions compounds of the gencral formula $C_nH_{n_2}Cl_2S$. Hübner and Gueront have lately made an observation, which also tends to snpport the idea of the existence of this body. A quantity of the pure ehloride, S_2Cl_2, was placed in a strong freezing mixtnre, and a current of dry chlorine passed through it for some time, the excess of this gas (that is, that existing merely in solution) being displaced by a stream of dry carbon-dioxido passed through for three or four hours. Whilst still in the freezing mixture a small quantity of the chloride was withdrawn and analysed, when numbers were obtained exactly agreeing with those required by the formula Cl_2S.

We have repeated this experiement with precisely the same result. A quantity of pnre S_2Cl_2 was first prepared; it boiled constantly at 136° to 137°, and was analysod with following results:—

	Calculated		Fonnd I.	Fonnd II.
S_2	64	47·42	—	—
Cl_2	71	52·58	52·48	52·67
	135	100·00		

About 20 grms. of this liquid were then saturated with chlorine in the manner described by Hübner and Gueront; after the excess of chlorino had been removed by carbon dioxide, it yielded the following numbers on analysis:—

	Calculated		Found I.	Found II.	Dumas.	H. & G
S	32	31·07	—	—	31·9	30·5
Cl_2	71	68·93	69·25	69.06	68·1	69·3
	103	100·00			100·0	99·8

The existeuce of this body would therefore appear to be fully proveu, for it is scarcely possible that such an agreement can be the result of an accidental coiucidence.

From these experiments, therefore, we draw the same conclusions as those deduced by Hübner and Gueront, viz.—that there exist two compounds of chlorine and sulphur analogous to the oxides of hydrogen. First, a non-volatile chloride, having the formnla SCl_2, corresponding to peroxide of hydrogen $_2Cl_2S = S_2Cl_2 + Cl_2$.

It will be at once apparent that in one respect the analogy between these chlorides and the oxides of hydrogen is incomplete, in so far that the most stable oxide of hydrogen, is water, into which the dioxide is easily converted by heating, whereas the reverse of this happens with the corresponding sulphur chlorides, the most stable compound being the S_2Cl_2, into which body and free chlorine the SCl_2 is resolved on heating.

ON THE CAUSES OF THE PHENOMENA OBSERVED WHEN THE BESSEMER FLAME IS VIEWED THROUGH COLOURED GLASSES.

By J. SPEAR PARKER.

In a formcr communication I described the appearances seen when the Bessemer flame was observed through a eombination of a blue and a deep amber or orange glass. I should not be surprised if others have failed in obtaining such well marked alterations in the colour of the flame as I there mentioned, for a very small variation in the depth of colour of the glass used is sufficient to mar the effect. Out of two dozen glasses obtained ostensibly of the same colour, I was only able to select four or five which gave the required result. If either the bluc or the orange be too deep, the flame has a reddish appearance throughout, only showing different shades of red and crimson; if, on the other hand, the colour be not deep enongh, the flame at the beginning and end of the process is more of a light orange than crimson, and during the period in which the carbon spectrum is exhibited appears of a much greener colour. The combination may be a little varied, however, without any great detriment if a little deeper bluo be compounded with a somewhat lighter orange or *vice versa*. I anticipated that the changes in colour of the flame when viewed throngh these glasses were owing to the nature of the spectrum given by the flame, and an examination of the absorption exercised by these glasses has confirmed my conjecture. As before, the spectroscope I used was a direct vision instrument with five prisms; on placing the blue glass before the slit and viewing direct sunlight, a spectrum was obtained containing well-defined dark bands. The least refrangible portion of the spectrum from A to a little beyond B was transmitted apparently without any diminution of brightness, then a very intense black band appears extending beyond C; another dark band occurs with the line D in the centre, and between these two partial absorption takes place, only a faint reddish light being visible; on the termination of the band beyond D, a elear bright space occurs in the yellowish green, and again a broad absorption-band, not so dark as those previously mentioned extends beyond the lines E and *b*, the bluc and more refrangible portion being freely transmitted. If a donble thickness of glass be interposed, the space from near B to beyond D appears as one broad dark band, while the light admitted in the yellowish green has been more rapidly absorbed than that in the red. With one thickness of orauge glass, the rod, orange, and yellow are freely transmitted, but tho more refrangible rays are absorbed with gradually increasing intensity till light is scarcely visible beyond F. With two thicknesses, though the red is little affected, even the yellow seems scarcely so bright by comparision, and all is darkness beyond E. With the combiuatiou of ono blne aud ono amber used for observing the Bossemer flame, the bright red band is seen as through blue glass, then the first dark band, again faint reddish light, tho second dark band, the bright yellowish green space, again a broad absorption-band, while tho bluo and voilet aro dimly visible. Withont further experiment this explains why increased depth of either eolour shonld render the flame as seon through the combination redder, for both glasses absorb the green and bluo more rapidily than the red rays; henco, if these were first balanced, increased depth would cause tho red to predominate. An examination of the

Bessemer flame by means of the spectroscope, with a blue glass interposed, shows the cause of the curious alterations in the colour, and why they agree with the indications of that instrument. When the carbon spectrum was fully developed, I found that the most prominent and brilliant group of lines occurring in that spectrum—the first in the green—fell in the centre of the second bright space. The potassium line is visible in the extreme red, but the lithium line, on the contrary, falls in the first dark band and is invisible; the first red group in the carbon spectrum is almost obliterated, and there is but a faint indication of the sodium line, then appears the bright space with the triple group in the centre, the remaining green lines, &c., being again obscured. Hence when the flame is first observed the red light predominates, the flame appears crimson. As soon as the carbon lines flash through the spectrum, yellow flashes are seen through the glasses, and shortly the flame presents the appearance of a light gamboge-yellow, a rose-coloured cone in the centre, and crimson edges. The production of this yellow, I think, is an additional illustration of the compound nature of that colour, for the red which previously predominated has added to it additional green light (in consequence of the appearance of the group of bright lines) and the result is yellow. However, it might be explained on the old principle, that the green being of a yellowish tint, the red and true green neutralise, the excess of yellow predominating. The central rose-coloured cone corresponds to the hollow of a Bunsen's flame, where no combustion can occur, and consequently the characteristic spectrum is not produced. With regard to the crimson edges, it is possible that here the carbon lines are not developed, complete combustion having occurred. In the "spiegel flame," as I before remarked, the green groups are brighter and more prominent than in the ordinary spectrum, and this gives a greenish yellow hue when seen through the glasses. I think the slightly different appearances observed by Mr. Rowan, and Professor Silliman, are easily explained. Mr. Rowan used two blue glasses, which though doubtless of a lighter tint than the one I employ, together caused the red to predominate throughout, as previously explained. Professor Silliman, while using one blue, used two light yellow glasses; hence the absorption of the more refrangible blue and voilet might not be sufficiently complete, and the blending of those colours would cause the ashy blue, &c., which he observed. As these changes are shown to be owing to the disappearance of the carbon lines, the glasses may be used with greater confidence in the accuracy of their indications; and for use in the workshop are much better adapted than a delicate instrument like the spectroscope.

THE MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the executive committee of this Association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, September 26th, 1871, Hugh Mason, Esq., Vice-President, Ashton-under-Lyne, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, which on that occasion was for two months, and is given in abstract as follows:—During the past two months 386 visits of inspection were made, and 805 boilers examined, 484 externally, 9 internally, 11 in the flues, and 301 entirely, while in addition 10 boilers were tested by hydraulic pressure. Seven of these hydraulic test were ordinary ones, simply to ascertain the sufficiency of boilers already in work, while in the other 3 cases the boilers were new ones, and were tested by hydraulic pressure, as well as specially examined, both as regards their construction and complement of fittings, before leaving the maker's yard. In the 805 boilers examined, 103 defects were discovered, 11 of them being dangerous. Furnaces out of shape, 3,—2 dangerous; fractures, 19—1 dangerous; blistered plates, 11—1 dangerous; internal corrosion, 21—3 dangerous; external ditto, 11; internal grooving, 4; feed apparatus out of order, 2; water gauges ditto, 6; blow-out apparatus ditto, 4; fusible plugs ditto, 2; safety-valves ditto, 9; pressure gauges ditto, 4—1 dangerous; boilers without feed back pressure valves, 4; cases of over pressure, 3—all dangerous.

Overheating of Furnace Crowns when Covered with Water.

It has already been stated in previous reports that furnace crowns may be overheated even when covered with water, and this subject was referred to at considerable length in the Association's Printed Report for May and June, 1869, in which chemical analyses were given of various feed waters producing these results, thus showing that furnace crowns were apt to be injured when the water contained a large amount of carbonate of lime, more especially if grease were introduced into the boiler. During the past month, another case of injury to furnace crowns from this cause has been met with. The boiler in this instance was of the plain Lancashire class, 30 feet long, by 7 feet in diameter in the shell, and 3 feet in the furnace tubes. The furnace tubes were strained from one end of the boiler to the other, the first five plates, reckoning from the front end, being fractured at the line of rivets, and the third and fourth plates distorted and bulged. The boiler was in regular work at the time, and both engineer and stoker testify to there being plenty of water in the gauge glass. Fortunately the owner at the recommendation of the Association had had each of the tubes strengthoned with angle iron hoops, which evidently did good service and came to the rescue of the weakened tubes, or in all probability the bulging would have extended until the plates had rent and explosion resulted. This boiler was fed from two sources, one a brook which had served other works, and the other a tank, into which water was pumped from a well, and heated by the injection of the exhaust steam from a high pressure engine. On an analysis it was found that this well water contained 16·3 grains of carbonate of lime, and 23·9 grains of sulphate of lime per gallon, while on examining the boiler internally, a great deal of grease was found therein, so that there can be no doubt that the overheating of these furnace tubes was due to the presence of carbonate of lime, coupled with the grease introduced to the boiler. It appears that the boiler attendant had recently been changed, and that the new comer had not opened the blow out-tap as frequently as his predecessor. This may have aggravated the evil, and brought things to a crisis. In such cases blowing out from the surface is of great value, and this had been recommended in this instance, but its adoption was delayed.

Another case of injury to a furnace crown through overheating when covered with water, was met with in a small Cornish boiler, 4 feet 6 inches in diameter and 13 feet long. This boiler had been but recently enrolled, and the injury was met with on the first examination, when it was found that the second and third plates from the front end were bulged down immediately at the crown for a depth of nine inches. There seems to be no doubt as to the furnace tube having been covered with water at the time. The manager of the works had but just been to the boiler to examine the pressure gauge and height of water in the glass, both of which he found satisfactory, when, immediately on leaving the boiler, the fireman shouted after him that something was wrong. On his return the water was yet found well up in the glass. When the Association's inspector got inside the boiler on the following day he found a large quantity of greasy slimy deposit therein, which smelt strongly of tallow, which it appeared it was the habit to introduce every cleaning time; while although the boiler was frequently laid off for cleaning, there was some difficulty in removing the slimy deposit on account of two longitudinal stays which prevented access to the bottom. The bulging of the furnace crown in this case is attributed to the action of the greasy slimy deposit, which would tend to keep the water off the plates. The remedy for this would be to keep the grease out of the boiler, as well as to clean and blow out more frequently.

Explosions.

On the present occasion I have nine explosions to report by which seven persons were killed, and twenty-two others injured. In seven of these cases the scene of the catastrophe has been visited by officers of the Association, while in two, viz., Nos. 29 and 30, in which other engagements prevented this being done, I have been kindly favoured with particulars by an engineer who had had an opportunity of making an investigation. Details of these explosions will be found below. Not one of the explosions referred to in this report arose from boilers under the charge of this Association. In addition to the explosions enumerated above, another may be briefly mentioned which sprung from a sulphur pan at a chemical works. This pan was heated by steam from a boiler at a pressure of 35lb., and gave way at the top from want of adequate stays. The telegraph wires close by were broken, but fortunately no personal injury inflicted. The mention of this may possibly prove of service to those who are employing sulphur or other pans heated with steam, by showing the importance of having such vessels adequately stayed.

In addition to the explosions that have occurred during the past two months in this country, two others of such magnitude have taken place in America that it may not be out of place briefly to refer to them on this occasion. The first of these, which occurred on Sunday, the 30th of July, sprung from a boiler on board a ferry boat termed the *Westfield*, which plied on the Staten Island ferry, and was the property of the Staten Island Railway Company.* At the time of the explosion the steamer was lying at her moorings at Whitehall Landing, New York, and there were between 200 and 250 people on board, most of them standing immediately over the boiler. Of these 185 were injured, 62 of them being killed.†

* The particulars herein given of the *Westfield* Explosion are gathered from various sources, viz., the "Engineer" of August 18th, page 103; August 25th, page 121; and September 1st, page 145. Also from the August number of "The Locomotive," published at Hartford, Conn., U.S., as well as from an extra number of that journal for the same month, &c., &c.

† Later accounts give the number of persons killed as 104.

The boiler was of internally-fired multitubular construction, somewhat similar in its general form to those of the locomotive class. Its internal arrangements however varied somewhat, the flue tubes not passing directly from the fire box to the smoke box, bnt running in the first place into a combnstion chamber at the back of the boiler, and then returning through another series of tnbes to the chimney immediately over the fire box. Its dimensions also were very different to those of the ordinary locomotive boiler, its diameter being as much as 10ft., and its length, as far as can be ascertained from the accounts given, being 17ft. in the cylindrical part of the shell and 7ft. in the fire box, making 24ft. over all, while the thickness of the plates in the cylindrical portion of the shell was nine thirty-seconds of an inch, and the nsual pressure at which the boiler was worked 25lb., the safety-valve having been seen to blow but a few minutes before the explosion with steam at a pressure of 27lb.

The boiler failed in the cylindrical portion of the shell, one of the belts of plating being ripped out, tearing all the way round at the circumferential line of rivets on each side of it. This separated the front end of the barrel of the boiler from the fire box, in consequence of which the front end was blown forwards into the bow of the vessel, and the fire box thrown backwards a little to one side, while the circumferential belt of plating was flattened out, and blown laterally against the port side of the vessel. With regard to the cause of the explosion, it is reported that an examination of the fragments showed that the boiler was in anything bnt a satisfactory condition. At a ring seam of rivets, through which one of the rents ran, there was found an old crack about 50in. in length, and at a longitudinal seam of rivets on the right hand side of the boiler there was * another crack about 18in. long, while the plate was deeply channelled. The American authorities have conclnded that the primary rent occurred at the circumferential seam of rivets, weakened by the flaw 50in. in length just described. This view, however, appears to admit of question. In boilers plated circumferentially with the longitudinal seams overlapping one another so as to break joint, as in the boiler under consideration, circumferential rents rarely develope longitndinal ones, though longitudinal rents frequently develope circumferential ones. It would appear most probable that the primary rent occurred in the neighbonrhood of the longitudinal seam of rivets on the right hand side of the boiler, where it is stated that the plate was weakened by channelling, and also by a crack abont 18in. long. A longitudinal rent started by this crack wonld extend across the belt of plating, and, arriving at the circumferential seams of rivets bounding it on both sides, would run entirely ronnd the boiler, and cnt a belt or ribbon out of the barrel. This would sever the tie between the two ends of the boiler, when they would fly apart in opposite directions, while the central belt of plating would be shot towards the port side of the boat, the opposite side to that on which the primary rent occurred. This is just the direction of flight that the parts assumed. An explosion, in which the development of the rents was very similar to that described above, occurred at Norwich, on the 25th of September, 1866, particulars of which were given in this Association's Printed Report for December, 1866. In that case the rent started at a flaw close to a longitudinal seam of rivets, when, having run across the belt of plating, it assnmed a circumferential direction, and, running right round the boiler, ripped out a complete belt, just as above. Had the primary rent occurred at the circumferential seam of rivets, the boiler, instead of being separated into three fragments, would in all probability have been separated into two merely, jnst as plain cylindrical, externally-fired boilers are separated when they fail at a ring seam of rivets. Bnt whichever may have been the first seam in the boiler to yield, whether a circumferential or longitudinal one, it is clear that the boiler was altogether unfit for work, and that it ought not to have been used, while the explosion shows the absolnte necessity of all boilers being subjected to competent periodical inspection, more especially where the safety of so many persons is concerncd, as in this instance. It is worthy of interest to note that the boiler in question was under Government inspection, that inspection consisting simply of the application of the hydraulic test, unaccompanied by examination It appears that this boiler had been tested by the U. S. Government Inspector with water pressure on the 12th of June last, up to 34lb. or 40lb. on the inch, and pronounced by him to be safe to work with steam at 25lb., while a certificate of safety was given in July, and hnng np in the saloon of tho boat for the assurance of those who travelled therein that no danger was to be apprehended.

Another instance of tho effect of what may be termed a "blind" hydraulic test, is given in an American scientific paper. The *Middleton*, a boat running on the same line as the *Westfield* on which the explosion referred to above took place, was inspected since the occurence of that catastrophe. The inspection was made on the 9th of August, the boiler being subjected to a hydrostatic pressure of 37lb., and standing the test. After this test the inspector made an external examination, removing a portion of tho covering of the boiler, and administering light raps with a hammer. This brought on a trickling of water, the crack from which it sprung soon widening into a rupture, and allowing the water to gush ont into the faces of the inspector and his assistant. On hammering the other side of the boiler similar rents were made. The *Middleton* was immediately taken off the route for repairs, a new boiler being absolutely necessary. Thus it appears that this boiler was in no better condition than that of the *Westfield*, and that it had a narrow escape of scattering its living freight, killed and maimed, in all directions. Under the cold water test simply it would have passed, and a certificate of safety would have been issued. These facts are worthy of the attention of those who recommend that the adoption of a "blind" hydraulic test should be enforced in this country by the Government, in preference to inspection, this plan being advocated on the score of cheapness. It is thought that much consideration would be reqnired before such a course should be adopted, and that while there would be a great diversity of opinion as to the efficiency of such a system, there can be no doubt that competent inspection would have prevented the explosion under review, and saved the 104 lives sacrificed thereby. At the inquest consequent on this explosion, the jury found "That the explosion of the boiler was caused by a flaw in the iron, and neglect on the part of the engineer in carrying an over-pressure of steam. Further, that the Ferry Company were responsible for the disaster, as the defect could have been detected had they had a competent superintendent, engineer, and mechanic in their employ, and that therefore they were criminally negligent," adding that "they thonght that the Government system of boiler inspection as conducted was very imperfect." In consequence of this verdict, the president and superintendent of the company, as well as the engineer of the *Westfield*, were committed to gaol, though snbsequently released on bail. It is stated that "under the statnte applicable to the case, the offence is manslanghter in the third degree, the punishment for which under the New York code is imprisonment for not less than two years, and not more than fonr."

The second explosion which has recently occurred in America, sprung, like the preceding one, from a boiler on board a steam boat. It took place on Sunday, the 27th of August, sinking the boat in deep water, and injuring about 70 persons, some of them fatally. These are the only particulars I have by me at present. It may perhaps be added, that in the United States, during the year 1870, seven explosions sprung from boilers on board steam boats, killing 136 persons.

Before entering on the details of the explosions recorded in the table below, the particulars of one may be given that occurred in May last, but reference to which was deferred until the coroner's inquiry was completed.

An Explosion Springing from a Marine Boiler made of Steel Plates. Cause,—Internal Corrosion.

No. 15 Explosion, by which one man was killed and another injured, occurred at half-past four o'clock on the morning of Wednesday, May 3rd, on board a steam flat. The following is my report thereon to the coroner, which gives full details:—

"W. J. R. Dunstan, Esq., Coroner, Northwich.

"Dear Sir,—In accordance with your instructions I have investigated the canse of the steam boiler explosion that occurred at about half-past four o'clock on the morning of Wednesday, May 3rd, on board the steam flat *Development*, while passing Winnington, near Northwich, on the river Weaver, on her way from Winsford to Liverpool. On Wednesday, the 10th of May, I examined the boiler when on board the steam flat, which was lying at the time near to the lock at Winnington, near Northwich, where the explosion had occurred, and after that on Friday, the 19th of May, I further examined the boiler at Winsford when taken out of the flat and lying at the works of———, the owner. Also, I have had two drawings made for the pnrpose of elucidation, showing the original construction of the boiler, as well as the mode in which it has rent, and now beg to report you on the cause of this disaster. The boiler was of a type now very generally nsed for marine pnrposes, being of multitubular horizontal construction, and cylindrical both in the shell and furnace tubes. The dimensions as nearly as may be were as follows:—Length, 9 feet 2 inches; diameter, 6 feet 1 inch in the shell, and two feet in the furnace tubes, while the flue tubes were 3 inches and $\frac{1}{8}$th in diameter, and 7ft. 3in. long. It appears that the boiler was made in the year 1864, and that its internal arrangements had been modified as recently as 1869, when at the same time the shell had been re-bottomed. When the boiler was first made all the plates of the shell were of steel, and were laid longitudinally, so as to run from one end of the boiler to the other. When the boiler was re-bottomed, iron plates were nsed, and these, as far as they extended, were laid circumferentially. The general thickness of tho steel plates as nearly as may be, was found at the examination to be $\frac{1}{4}$ of an inch, while that of the iron plates at tho bottom was

* See "The Locomotive," for August, published at Hartford, Conn., U.S.

⅜ths of an inch. With regard to the working pressure, the boiler was fitted with a single safety-valve of the ordinary lever constrnction, loaded of with a oast-iron ball, the diameter of the valve being 2½in., the weight the ball 42lb., and the proportions of the lever snch that with the weight at the end, the load wonld be about 85lb. on the square inch. The boiler gave way in the external shell, the steel plates rending immediately above the longitudinal seam of rivets at which the new iron plates at the bottom joined the old work, the rent running, however, not throngh the line of rivets but through the solid metal, a little above the edge of the overlap. This rent, which was the primary one, occurred at the right hand side of the boiler and at the back eud, when, after rnnning longitudinally for a length of 28in., it assnmed a circumferential direction, taking at one end the course of a ring seam of rivcts at the back of the boiler, and at the other end the course of a strengthening hoop encircling the shell. These circumferential rents ran for a length of about 6ft. ronnd the boiler, the plates opening out somewhat like a door on its hinges, tearing off at the part at which it hinged, and breaking itself into three pieces. It was from the rnsh of steam and hot water that took place from this opening that the engineer was killed, and the other man serionsly scalded, while in addition the boiler was spun round on its seat from the unbalanced pressure induced. With regard to the canse of the primary rent, I fonnd on examination that the boiler had been attacked internally by corrosion conseqnent on the acid character of the feed water. This corrosion had eaten out a groove or furrow immediately above the longitudinal seam of rivets in the vicinity of which the primary rent occurred, and throngh this furrow the primary rent ran. This internal corrosion had so reduced the thickness that at the edge of the fracture the plate was only $\frac{3}{16}$th of an inch at one part, and somewhat less than ⅛th of an inch at another. It is to the reduction of strength consequent on this wasting that I attribute the explosion. It should perhaps be stated in passing that rnmour says that the engineer was not very careful in the treatment of the safety-valve, and that at times he overloaded it. On this point, however, I am not able to be precise. Had the safety-valve been overloaded of course it would have accelerated the explosion, but whether it was overloaded or not it is clear that the plates were dangeronsly wasted by internal corrosion, and to this wasting the explosion may be fairly attribnted. As the object of such an inquiry as the present is to prevent similar disasters in the fnture, as well as to ascertain the cause of those that have already occurred, I may perhaps be permitted to add a couple of snggestions :—Firstly, with regard to the boiler :—Experience with the wasting of plates from corrosion shows that whatever the strength of steel may be, it is not desirable to construct a boiler of such thin plates as a ¼ of an inch only, or even of $\frac{5}{16}$th of an inch as they were stated originally to have been, and this remark is of donble force where boilers are of such a constrnction as to render internal examination, as in this instance, somewhat difficult. In well-proportioned stationary boilers there is plenty of room for a man to get inside and bring himself face to face with nearly every part. In marine, locomotive, and portable boilers this however is not the case from the number of tubes with which they are crowded. It will readily be seen for a plate to have a margin of only ⅛ of an inch in thickness in a boiler that cannot be readily and freqnently examined is not a safe course, and it is recommended that nndcr similar circumstances the thickness of the plates should not be less than $\frac{7}{16}$ of an inch. Secondly, with regard to the safety-valve :—It is important that every boiler should be fitted with a duplicate safety-valve, and it is thonght there are no valves more adapted for such a scrvice as the one under consideration than those of the external dead weight pendnlous class. These valves cannot be easily overloaded. They rcquire a considerable amount of weighting to prodnce any effect, in consequence of which, if tampered with in this way, they become so bulky as at once to attract attention. Were the valve carried up a few feet on deck it wonld be open to view, and this would be a great protection. It conld then be seen by the captain in charge, as well as by all hands on deck. Also it could be seen by the gatesman when passing through the locks, and by those on board the other flats when passing one another, as well as by those walking on the banks of the river. All these parties would have an interest in crying down any overloading, and the valve being thus exposed would derive protection from its publicity. These are the two snggestions I would venture to make for the prcvention of such catastrophes in future,—firstly, that snch boilers should not be made of plates thinner than $\frac{7}{16}$th of an iuch in thickness, and secondly,—that they should be fitted with a safety-valve of external dead weight pendulons construction, carried up on deck so as to be in the sight of everybody, while to these two snggestions I wonld venture to add a third, viz., that all boilers should be placed under competent independent inspection, and not merely left to the oversight of the ordinary attendants, who thongh making frequent examinations sometimcs fail to detect weak places, which may lead, as in this case, to an explosion and the loss of their own lives, "LAVINGTON E. FLETCHER, Chief Engiucer."

At the inquest the jury found that "the explosion was the result of incompetent inspection by the owner's superintending engincer." The coroner suggested the insertion of the word "accidental," but the jury objected on the gronnd that "the explosion would have been avoided by a thorough examination by a compctent engineer." Ultimately the word "misadvcnture" was introdnced.

The following is the tabular statement for the past two months :—

"TABULAR STATEMENT OF EXPLOSIONS FROM JULY 22ND, 1871, TO SEPTEMBER 22ND, 1871, INCLUSIVE.

Progressive No. for 1871.	Date.	General Description of Boile	Persons Killed.	Persons Injured.	Total.
23	Jnly 17	Single-flued, or 'Cornish' Internally-fired	0	0	0
24	July 28	Plain Cylindrical, egg-ended Externally-fired	0	1	1
25	Aug. 1	Portable Multitubular Internally-fired	1	7	8
26	Aug. 3	Vertcl. Cylindrical, Rag Boilr. No fire, heated by steam...	1	1	2
27	Aug. 17	Single-flued, or 'Cornish' Internally-fired	2	0	2
28	Aug. 28	Double-flued, or 'Lancashire' Internally-fired	1	2	3
29	Sept. 1	Marine Multitubular Internally-fired	2	2	4
30	Sept. 2	Plain Cylindrical, egg-ended Externally-fired	0	5	5
31	Sept. 16	Single-flned, or 'Cornish' Internally-fired	0	4	4
		Total	7	22	29

(*To be Continued.*)

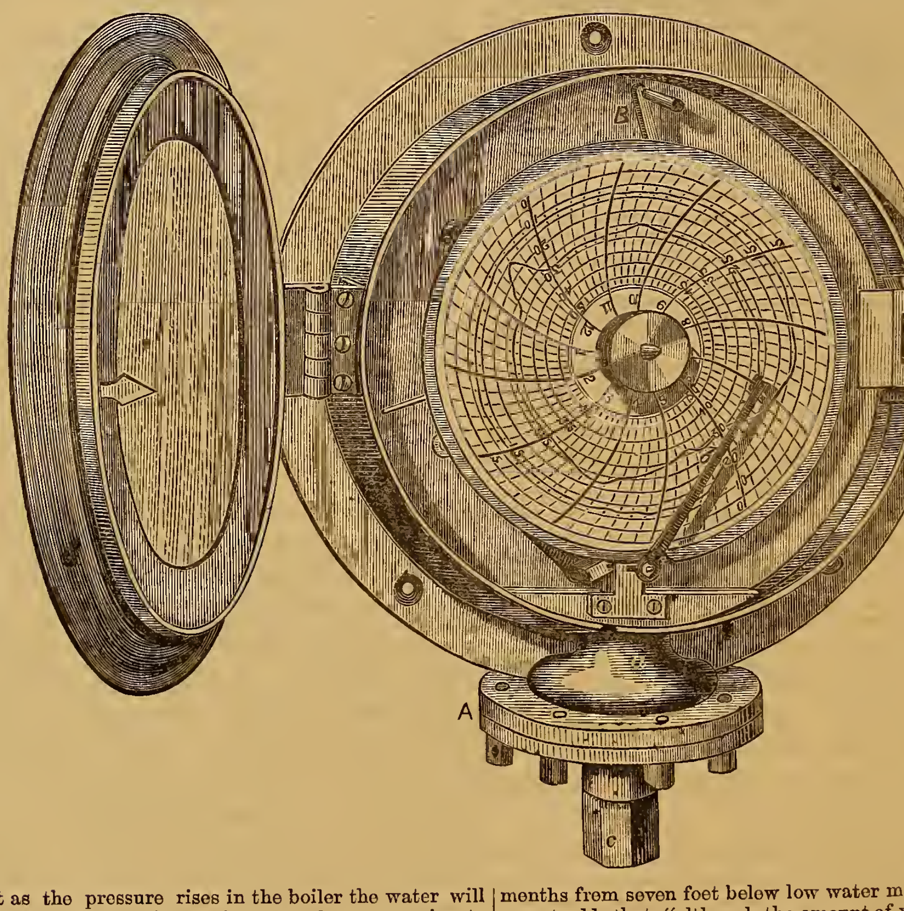
OLD SILVER MINES IN SCOTLAND.

In exploring the old workings near Bathgate, an old hammer has been found in one of the silver mines. The handle is round, two inches in diameter, and about 14in. in length. The head is of iron and anchor-shaped. The main pit, or entrance to the whole series of pits and mines, is about 9ft. by 6ft. in width, and 21 fathoms deep. The walls are of solid limestone rock, finely chiselled, and bearing innumerable initials of individuals, among which is "C.H., 1698," and beneath it a coat of arms. From the bottom of this pit, shafts runs in all directions; and at the termination of one of these, another pit, several fathoms in depth, has been discovered. At the bottom of this second pit other mines have been found, and at the extreme end of one of these there is found a third pit, which has not been thoroughly explored on account of the quantity of standing water contained in it. On the walls of this last pit the year "1498" is carved. It is snrmised that the workmen had drawn the water in bucketfuls from the lowcst pit, condncted it to the bottom of the second pit, and, by the sam means, raised it from the second to the third pit, whence it ran along a main level, and discharged itself into a stream in the neighbonrhoo d where the metals were crushed and washed. The varions veins havebeen cleanly wrought out, and one of them there was no less than 20ft. in hcight The rnbbish had been neatly re-packed into the veins to save the labour of carrying it to the pit-mouth. The workmen had descended the first pit by means of a windlass, and the remains of large beams are still visible there ; but it would appear that they had descended and ascended the other pits by niches cut out of the solid rock. It is thought by experienced workmen that the only way these mediæval miners conld have taken the water from the mines must have been by means of a level cut through the Bathgate hills, about a mile and a half in length ; and an investigation is to be made to ascertain the correctness of this supposition. Besides silver and lead, platinum has been fouud in abundance, and the mines are now being worked energetically.

DAVIS'S PATENT PRESSURE RECORDER.

We herewith illustrate an invention the useful aim of which will be apparent at a glance. It is a simple apparatns for showing the steam pressure in a steam-generator, and for registering the variations in the same during any given time. It is the invention of Mr. D. P. Davis, a mechanical engineer of New York. A few words of explanation, having reference to the engraving, will make plain to our readers the construction and operation of the invention.

A diaphragm, like that employed in the ordinary diaphragm pressure gauge, is arranged within the chamber, A, the inlet, *c*, of which communicates by a suitable pipe with the water-space of the boiler. This diaphragm actuates a sliding rod extending up through the neck, *a*, the upper end of which rod connects with the short or lever-like arm of an index-finger, *b*, the free end of which carries a pencil that has its point in contact with the graduated card placed npon the face of the disc enclosed within the circnlar case or shell. This disc, and, of conrse, the dial upon it, has a rotary movement around its axial pivot, being revolved at any desired rate of speed by clockwork arranged behind it in the rear portion of the case.



It will be seen that as the pressure rises in the boiler the water will be forced against the under side of the diaphragm in a proportionate degree, and the upward movement of the latter moves the index npward and inward toward the centre of the dial, its progress being marked by the impress of the pencil upon the dial; the degree of this movement, and, consequently, of pressure, being shown by the position of the pencil-mark at any given point with reference to the concentric lines. The diminution of pressure, of conrse, simply moves the pencil in a direction opposite to that given by the rising pressure. Simultaneously with the movement of the pencil, the nniform motion of the disc brings the curved radial lines, which indicate subdivisions of time, across the path of the pencil, so that the minimum, maximnm, and average pressure for any given period are recorded upon the dial, and may be readily read off therefrom. The clockwork is wound np by means of the pawl, B, which, with the dial, index-finger, etc., are enclosed by the hinged glass front, which may be locked so that the record cannot be tampered with by ill-disposed persons.

HARBOURS OF REFUGE.

An interesting Parliamentary document on this subject has just been published by order of the House of Commons, containing the quarterly reports of the engineers of the works in progress at Alderney, Dover, Holyhead, and Portland for the year ending on the 31st of last March. It appears from it that at Alderney the expenditure on works in the three preceding qnarters was £4,958, £1,945, and £1,549 respectively; and that the qnantity of stones deposited on the breakwater within the same dates was as nearly as possible 19,100 tons. The total cost of the works thus far amounts to £1,259,620, which is as nearly as possible £40,000 short of their estimated cost. The returns for Dover Harbour extend over the four quarters of the year. They shew that up to the end of March the amount certified as having been expended was £656,546, ont of a sum estimated at £725,000; the sum authorized to be expended for the year was £21,000; and the actual expense certified in nine months appears to be only £4,897; but for the first quarter there is no return given. It appears that the damage done to the staging by the storms of December 1869, was repaired by midsummer 1870; and that an average length of nearly 150 feet of the pier was raised in 12 months from seven feet below low water mark to the quay's level. The report adds that, "although the amount of work done has been considerable, it would have been much greater but for the destruction of the contractor's staging, which took place during a heavy storm in the winter of 1869-70. In order to replace the piles which could not be procured in England, the contractors forwarded the necessary orders to the Baltic, bnt these could not in any case have been procured until the breaking up of the ice, which occurred at an unusually late period of the year. Before the shipment of them had been completed the blockade of the Baltic prevented many of the timber vessels leaving the ports, and bnt for the accidental circumstance of Messrs. Lee having some works in Holland where similar timber was used, and from which a limited supply was afterwards obtained, the delay to these works would have been even more serious than it has been." The average number of men daily employed upon the works appears to have been 89. The report on the progress of the breakwater at Holyhead is far more elaborate. No return apparently is given of the "amount authorised for these works;"

at all events that column is left blank; but the amount expended in each of the four quarters is £2,306, £7,584, £7,550, and £2,684 respectively, making a total of expenditure up to date from the commencement, of £1,437,248. The general description of the works here includes:—The construction of two breakwaters for the enclosure and shelter of 260 acres of deep water in the West Bay of Holyhead, according to the design of 1845, for a refuge and packet station; also for railways in the quarries and round the harbour. The construction of a landing pier for packets within the harbour, as subsequently designed. The formation of a beaching ground on the south shore of the harbour, suitable for careening. The lengthening of the north breakwater, as designed in 1845, by 2,000ft., for sheltering that portion of the bay lying between the New and Old Harbour, and making it a safe and commodious roadstead of upwards of 370 acres of deep water. The lengthening of the north breakwater by an additional 500ft., which will increase the roadstead to 500 acres of deep water. The construction of a wooden pier, commencing near the end of the North Pier of the Old Harbour, for the temporary accommodation of the proposed new mail packets, &c. The extension, in a westerly direction, of the wooden pier, and for raising and altering of a portion of the North Pier in the Old Harbour. For strengthening the wooden pier in the Old Harbour, and for erecting a shed covering thereon. The work in Old Harbour for postal accomodation. Under the head of "General Remarks," Mr. Hawkshaw, the engineer, reports that on the whole the progress in each of the quarters has been satisfactory, no less than 77,074 tons of stone from the mountain quarries have been deposited at the end and other parts of the breakwater; and no less than 2,962 vessels have sought shelter within it during the same period. In the last of the four quarters, according to Mr. Hawkshaw's report, "the upper portion of the superstructure of the north breakwater has been joined to the head, and the head built to the level of the parapet; also part of the parapet and paving has been set; 17,906 cubic feet of masonry have been set during the quarter at the head, making a total of 110,470 cubic feet in the year. It may be remarked that the total of the original estimated cost of the works at Holyhead was £1,536,000. At Portland the general description of the works includes the formation of an inner and outer breakwater, terminating at 8,500ft. from the shore, and sheltering 2,130 acres of Portland Bay, with coaling and watering establishment and adjunct works; construction of timber jetty for protection of boats belonging to her Majesty's ships; maintenance of works generally; works and services for Naval and War Departments, and supply of stone for Her Majesty's dockyard extension works, Marine Barracks, and convict prisons. It may interest our readers to learn that during the year no less than 13, 106 tons of Portland stone have been quarried and squared by the convicts in the breakwater quarries, and shipped for use at the Dockyard Extension Works at Chatham and Portsmouth, and at the Marine Barracks at Plymouth, and that about 26,000 tons of rough stone were added to the breakwater. The total quantity of stone deposited in the breakwater mound and the foundations of the three circular heads, from the commencement of the works up to the time of completion during the quarter now ended, has been 5,731,376 tons. The average of workmen, including foremen, carpenters, divers, &c., has fluctuated between 68 and 85, while that of convicts employed in the quarries has ranged between 458 and 514. The total of the amount hitherto expended at Portland from the commencement of the works up to the date of the last report (March 31), less cost of stone and other materials supplied to Her Majesty's Dockyard Extension Works, was £1,167,852.

NEW TICKET-PRINTING.

A short time ago a number of persons, scientifically accquainted with the mechanism of printing, assembled by invitation at the printing offices of Bebro's Patent Printing and Ticket Registering Company, in Old-street, City-road, for the purpose of observing in action a new process of ticket-printing, which combines at once naming, numbering, and registering. The system is the invention of Mr. Marcus Bebro, of Manchester, whose object has been to execute a complete scheme of tickets for the detection of fraud in public vehicles, theatres, &c.; a machine being required which produces consecutively numbered tickets in a continuous roll from one up to a thousand, divided into proper lengths, each length perforated, and having printed matter impressed on its surface. After considerable trouble a machine was at length devised, which is capable of printing on both sides of continuous rolls of paper or cardboard, numbering consecutively and perforating 1,000 tickets per minute when the machine is work by hand. When steam-power is applied to it rapidity of production will, of course, be proportionately increased. The printing is done by an ingenious adaptation of the usual cylinder process, the types being placed on one or two cylinders, as may be required for printing on one or both sides of the tickets. In passing from one printing cylinder to the other, the strip of paper is brought into contact with an intermediate cylinder, which makes a series of perforations in the line of division between the respective tickets. While the perforation is being executed the consecutive number is impressed from beneath. The part of the machine by which the numbering is done is quite novel and very ingenious. It consists of a cylinder between two and three feet in diameter and about the same in length, on the periphery of which are arranged figures, ordinary moveable types, from 1 to 3,000. By placing the numbers in a continuous spiral line round the cylinder, and making the latter move on its axis at a certain rate, the numbers are presented and printed from in succession, with unfailing accuracy. Distinct from the printing machine is a patent register box, or receptacle for the coil of tickets, which are issued from the register as required. This part of the process is particularly applicable to tramways and omnibuses, and is actually in use with success on the line of tramway in the City-road. The tickets being consecutively numbered, there is adequate indication of how many have been issued, and there is an unfailing check on the distributor. The system is also applicable to tickets for railways, passenger and luggage traffic, steamboats, pawnbrokers' establishments, colliery works, theatres, concerts, and all places of public amusement, racecourses, public gardens, advertisements, balloting and postal cards, postage and receipt stamps. It is estimated that a saving of not less than 50 per cent. upon the present mode of printing will be effected by Mr. Bebro's improved machinery. The patentee has visited Austria and Prussia, and has obtained a patent from the Government of the former country. The machine was freely exhibited, and all its capabilities were shown, to the persons who were asked to inspect it; and there seemed to be but one opinion of its simplicity and its capacity for carrying out fully the object it is intended to attain. It may be added that it has met with the approval of many scientific, and practical gentlemen; and several railway companies are in communication with the patentee in reference to the adoption of the apparatus on their lines.

USE OF THE HYDRATE OF ALUMINA IN CLARIFYING SUGAR SOLUTIONS.

The means known up to the present time, for clarifying sugar solutions which are to be submitted to optical examination, do not always fulfil their object; they have had the effect, noticeably in these last years, of throwing upon the market, a larger and larger quantity of raw sugar, a clear solution of which, suitable for examination with the polariscope, can only be attained with difficulty, or incompletely. The cause of this, it seems, should be attributed to the processes employed to effect solution, or to the existence of sugars which are too neutral. These are especially the white products, which giving high results with the polariscope, have no call, so to speak, for the use of the acetate of lead, and do not need any particular clarifying but have a turbid aspect, and give, after filtration, a solution which is not white, but which has been designated by the name *opalescent*. These sugars, and indeed many others, which resist clarification by lead solutions, can frequently by the addition of tannic acid, the use of which Mr. C. Scheibler has extolled for many years, be brought into such a state that they will give a precipitate with acetate of lead, and a clear liquid after filtration. But since quite recently, various kinds of tannic acid have been introduced into commerce, which have the power of rotating the polarised ray to the left, this new method has become equally ineffectual. It follows that some other suitable means of clarifying sugars should be recognised as the proper one. In this state of affairs, were a change of colour is of less importance than the bleaching of a sugar-solution, Mr. Scheibler advises the use of hydrate of alumina, which has given him extraordinary results quite recently. Mr. Albert Langen, of Cologne, made on this occasion numerous experiments at the laboratory in Berlin, which have proved that the use of the hydrate of alumina is convenient, and except in the case of a turbid solution, is without action on the phenomenon of polarisation. As to the method of making the hydrate of alumina, the best way is to prepare it by the ordinary method in large quantities, *i. e.*, sufficient to serve for several tests. Add to a not too concentrated solution of sulphate of alumina, or alum, an excess of caustic ammonia; allow the precipitate which forms to subside, decant or remove by a siphon the supernatant liquid, and wash until every trace of the salt or the ammonia has disappeared, and also until red litmus ceases to turn blue with it. A voluminous jelly of hydrate of alumina remains which should be kept in a well-corked bottle. Place in a small flask holding 50 c.c. 13·024 grammes of the sugar to be clarified; add to it by means of a pipette drawn out to a point 3 to 5 c.c. (or more according to the degree of dilution,) of hydrate of alumina. Shake and filter. By proceeding thus a liquid is always obtained, extraordinarily clear or white, with a partially changed colour, which may be perfectly polarised.

To appreciate the diminution in volume which results from the introduction of a solid body, and renders the use of a small flask of 50 c.c. necessary, evaporate 10 c.c. of this same hydrate of alnmina, heat the residue gently, and weigh. Mr. Langen obtained thus 2 grammes of alnmina, and since the specific gravity is 4·15, it results that the alumina contained in 10 c.c. of the jelly, occupies only a volume of 0·048 c.c. But since in the test given above, only 3 to 5 c.c. or more is used, the diminution of the capacity of the small flask cannot amount, at most, to over 0·015 to 0·025 c.c. that is to say it amounts to insignificantly small quantities, wherefore if it does involve error, it is within the limits of errors to which those observations are always subject.—*Zeitzchrift des Vereins für Rübenzucker-Industrie.*

TRIAL TRIP OF THE "DORIS."

The *Doris*, 24, screw frigate, in charge of Capt. Charles Fellowes, C.B., and Staff of the Steam Reserve, made a highly satisfactory trial of her speed over the measured mile at Plymouth, on the 28th September, Since this fine ship has beon at Keyham she has undergone a thorough overhaul and extensive repairs, besides which her boilers have been taken out and re-tnbed. Tho trial of the *Doris* on the 20th September was unsatisfactory owing to insufficient steam through inferior coal, and even on the present occasion neither one of the seven kinds of coals which are classed as steam trial coal was used, as there is only a small qnantity of it at Devonport at present, and that is reserved for the Admiralty yacht *Enchantress*, and, althongh the *Doris* attained a higher rate of speed than on previous trials. she wonld doubtless have done still better with the other coal. The ship's draught was 19ft. forward, 20ft. 7in. aft; the wind west, force, 1 to 4; the sea smooth. Bar., 29.95; ther., 61. Six runs were made over the mile at full-boiler power, with the following result :—Mean speed, 11·528 knots per hour, revolutions, 54·18 per minute; steam pressure, 18lb.; vacnum, 24½in. forward, 25½in. aft. The mean of two rnns at half-boiler power were :—Speed, 9·893 knots per hour; revolntions, 45·7 per minute; steam pressure, 17lb.; vacnum, 25in. forward, 26in. aft. In circle turning at full speed the first circle was made to port, with all starboard helm, angle of rndder 22 degrees; the half circle occupied 2min. 47sec., the whole 5min. 57sec.; diameter of each oircle 550 yards. In the second to starboard, with all port helm, angle of rudder 19 degrees, the half circle took 3min. 21sec., the whole circlo 6min. 30scc.; diameter of circle 675 yards. Mr. Bardin, C.B., chief inspector of machinery afloat, was on board during the trial.

THE *Swiftsure*, 14, armour-plated iron screw ship, and the *Coquette*, 4, screw composite gunboat, were on the 30th September placed in the 1st Division of the Steam Reserve at Keyham, and arc to bc brought forward for commission.

LAUNCH OF A TURRET SHIP.

On the 30th September Her Majesty's twin screw armonr-clad turret ship *Hecate*, four guns, was snccessfully launched by the builders, Messrs. J. and W. Dudgeon, at their shipbuilding yard, Cnbitt-town.

The *Hecate* is one of four vessels, called the "Cyclops" class of Monitor turret ships, ordered by the Government about 12 months ago. Two were ordered from shipbuilders on the Thames, the third on the Clyde, and thc fourth on the Tyne. The *Hecate* is the second lannched. These vessels are intended for the defence of onr coasts and channel seas, and it is confidently expected that thcy will provc themselves good seaboats. Two vessels constructed on a similar principle have made cxcellont passagcs—one to Melbourne, the *Abyssinia*, built by Messrs. Dudgeon, and another, made for tho protection of our Indian possessions, to Bombay. Tho *Hecate*, of 2,107 tons burden by builders measurement, is 225ft. in lcngth, 45ft. in breadth, and has a depth of 16ft. in the hold. She is mado of iron throughout, and amidships a space about 120ft. in length is cnclosed, roughly speaking, by an elliptical breast work of defensivo armour-platiug 9 and 10 inches thick, backed by East India teak, and lined with two thicknesses of ½in. iron-plate. This bnlwark, impenetrable to shot and shell, is carried completely round the vitals of the ship, protecting tho engines, the apparatus to be used for steering in battle, and the powder magazines. Two tnrrets, similarly plated, risc abovo this breastwork, by which their rcvolving bases are protected. Each turret is pierccd for two 18-ton guns, which will throw shot and shcll weighing about 450lb. Tho gun carriagcs arc placed parallel to each othcr in tho turrot, and aro fitted with Captain Scott's compressor plates to counteract the recoil of tho gun. Bchind the carriago is placcd horizontally a cylinder fillcd with oil and fitted with a piston, against which tho carriage presses when the gun is fired, the elasticity of the compressed oil assisting to forcc thc gnn back into position. There are also india-rubber buffers to decrease the effect of tho shock. The turret is made to perform a complete revolution on its axis in les than one minute by means of a pinion worked by a small auxiliary engine, which is snpplied with steam from the boilers of the principal engines. Between the turrets and raised above them is an armour-plated pilot-honse, in which during an action the captain is to take his place and give his orders to an officer, who commnnicates them by telegraph to the engine-room and throngh speaking-tubes to those commanding in the turrets. Whcn the ship is not in battle her course will be directed from the hurricane deck, on which is the ordinary steering apparatus and a chart-honse. On this deck also the ship's boats, lifted by derricks attached to a light iron mast, are to be secured on "crutches," in rough weather. Ventilation is provided for by a downcast air shaft and steam fans, which will drive fresh air through light iron pipes, into all the compartments of the vessel. The armour-plated central portion of the ship has a double bottom, the space between the two skins being divided into water-tight cells, while the unprotected portions fore and aft are divided between decks into compartments separated by iron bulk-heads. When afloat the *Hecate* drew 8ft. 7in. forward and 11ft. 10in. aft, but when completely armonred and equipped her draught will be 15ft. 6in., the point of the ram with which she is armed being about 10ft. below the water line. There are no masts, the constructors trusting entirely to what Admiral Rous calls the "tea-kettle" for the means of driving the ship. She will be propelled by two four-bladed screws, worked by two pairs of engines of 250 nominal horse power, made by Messrs. Miller and Ravenhill on the banks of the Thames. The ship will be completed in the Millwall Dock, and will afterwards be sent to Devonport.

REPORT OF THE COMMITTEE ON WASTE IN COMBUSTION.

THE REAL PRACTICAL VALUE OF COAL AS A SOURCE OF POWER.

Coal being for all practical pnrposes the only agent employed in the production of heat, it is important always to keep in view its theoretical power in this respect, even though there appears to be but small hope of the realisation of this power in practice. The attention both of men of science and of practical cngineers has becn for some timc steadily directed to this matter, and although the perfection indicated by theory has not been, and probably never will be attained, approaches towards it are continually brought nearer.

If we examino the evidence of the first witness who appeared before the Committee, we find those positions placed in a fairly satisfactory manner. It will be known to most persons that, as stated, "one pound of pnre coal yields in combining with oxygen in combnstion theoretically an cnergy equal to the power of lifting 10,800,000lb. 1ft. high,," or, "the full theoretical equivalent of force for a unit of heat, that is to say, for the hcat necessary to heat 1lb. of water through 1 deg. Fah. is 772 foot-pounds. A pound of coal in burning shonld yield 14,000 nnits of heat, or 772 × 14,000 = 10,808,000. Mr. J. Anderson in his ovidence truly says, "the good which is now being done, I think, is entirely due to the knowledge of Joule's equivalent of heat and work being convcrtible. I believe that it is more due to that than any other cause, and this as a clue will lead in many directions." It may not be so generally known that the highest practical result which has been realized is 1,200,000lb., or less than one-eighth of the theoretical value, and this, "without counting the impurities of ordinary coal, which cannot be taken at less than 10 per cent." Theoretically, a pound of pure coal shonld evaporate about 13lb. of water; practically, a pound of ordinary coal does not evaporate 4lb. The best results are stated to have been obtained in the boilers of the Cornish engines, or in boilers constructed upon the model of the "Cornish boiler." From a careful set of experiments made some years siuce, this was shown to be dne in Cornwall to the accurate adjnstment of the quantity of air admitted to the fuel, and to a carefnl system of stoking. It is to be regretted that the samo amount of attention has not of late years beeu given to the economy of coal in the working of tho steam engines of the mines of Cornwall and Devonshire. Conseqnently, thero is a considerable falling of in tho reported duty, the coal not being so effectivcly burnt. This is, no doubt, partly dne to the engines having become old and worn. and conseqnently imperfect in action. But it cauuot be disguised that, in a great many cases, there has bcen, owing to this system, which has unfortunately for some time prevailcd in working our coppcr and tin minos, much carolessness, which has told matorially upon the effectivo powers of steam engines for all pnrposes. While referring to the results obtaincd with the Cornish engincs, it is important to remark that, in reply to a question asked by one of tho commission, a witness stated that the dnty of the Cornish engine was a "little abovc a million." This is to high. Referencc to the tables B, C, D, aud E in appendix, which give the "duty" of the bcst Cornish engines since 1814, will show that up to a ccrtain point there was a gradual increase in the number of pounds lifted 1ft. high by

the combustion of one bushel (94lb.) in the earlier tables, and of one cwt. (112lbs.) in the later ones. And that after the maximum had been obtained there was a steady decline in the effective power obtained. But the highest recorded duty is about 98,300,000 in 1857. The position which we have endeavoured to show as prevailing in connection with the steam engines of Cornwall is fully borne out by the following letter from Mr. Lean, who organised and has carried out the system of engine registry:—

"Marazion, January, 1870.

"Sir,—Permit me to bring under your notice the very serious decline in the average performance of the Cornish steam engines, You will observe in the table inserted below that from the period when the work performed by engines was commenced to be publicly reported in 1811 there was a continuous improvement up to 1843, when an average performance of 67,000,000lb., lifted 1ft. high by the consumption of 112lb. of coal, was reached. Since 1843 there has been an equally continuous retrograde course, so that at this time the average 'duty' of the engines has fallen off about 26 per cent. Or, to put it in other words, at this time full one quarter part more coal is consumed by the engines, on the average, than was necessary in 1843 to do the same work—an item of no small importance, especially in such a period of depression as the mining interest has been passing through.

Table of Average 'Duty' Performed by the Cornish Engines, per 112lb. of Coal, at the end of each period of five years, commencing with 1811.

Year.	Duty.	Year.	Duty.	Year.	Duty.
1811	20·4 mills.	1835	56·9 mills.	1855	54·8 mills.
1815	24·4 „	1840	64·8 „	1860	51·6 „
1820	34·1 „	1843	67·0 „	1865	50·2 „
1825	38·1 „	1845	66·1 „	1870	51·5 „
1830	51·5 „	1850	61·8 „		

"Thomas Lean."

Sir Charles Lemon in 1838 published a "table of the duty performed by steam engines in Cornwall from 1815," when the highest duty given is 26,400,000, to 1837, when it was 87,212,000; and on the occasion of some special experiments made on Taylor's engine in the United Mines the duty was got up to about 107,500,000. But this does not appear to have ever been the effective working power of any steam engine in Cornwall. Several steam engines in the waterworks of the London companies have done higher duty than this, as the table, Appendix F, will show. With rotary (fly-wheel) engines, worked by steam slightly over-heated, and with a tenfold expansion, it is stated that an effective power somewhat above the duty of the Cornish engine has been effected. The waterworks engines appear to give a higher duty. We therefore find that with arrangements acknowledged to be the most economical for burning coal, so that as little heat as is possible should be wasted, the highest practical result is still below one-tenth of the theoretical duty, or, as a witness states it, "under one-eighth, without counting the impurities of the coal, which cannot be taken at less than 10 per cent." But as even these may be regarded as exceptionally good cases, it becomes certain that, seeing the conditions under which the majority of steam engines have been worked, that not more than one-thirtieth of the whole theoretical value of the coal is at present realised in power. Having thus before them the duty which under the most favourable combination of care and skill is obtained from ordinary coal, the committee proceeded next to examine into the duty actually obtained from coal in ordinary manufacturing establishments and in its domestic use.

Iron Manufacture.

Our attention was directed, in the first instance, to the iron manufacture, which consumes in smelting of the ores and in the production of merchant iron more than one-fourth of all the coal raised in the United Kingdom. It is certain that until recently there has been both an enormous waste of fuel in the production of heat, and a considerable waste of heat when produced, in all furnaces in which it has been necessary to obtain an elevated temperature. Therefore we had to inquire if in the extensive processes in operation in the 670 blast furnaces which are in action in Great Britain, using not less than 15,000,000 tons of coal, there appeared to be any tendency to prevent this excessive waste; whether in the several branches of the manufacture—as the making of malleable iron and steel—in which an equal or a larger quantity of coal is burnt, any improved systems had been introduced or contemplated by which economy of coal had been or was likely to be effected.

Nearly all large manufactures, and especially those of iron, are placed within or close to our coal-fields. We have on evidence that some years since small coal "was treated almost entirely as a waste product, so much so that small coal could be had in any quantity at 4s. a Newcastle chaldron of from 2¾ to 3 tons, delivered into barges on the river." That which was true of the Newcastle district was more or less so of all the other large coal-fields of the kingdom. Under those circumstances it cannot be considered surprising that we do not discover that any effort was made in the direction of economy in the use of coal. "Things are now entirely changed with regard to the value of fuel." The small coal has, in various ways, been utilised, and consequently its price has been steadily increasing for several years. The witness already quoted says: "I may state that coal which was formerly sold at 4s. per chaldron is now sold at something like 8s. a chaldron, and that the very best Durham coke, which when we commenced our own blast furnaces to smelt the Cleveland stone could be bought at 6s. 6d. at the pit, now fetches something like from 10s. to 10s. 6d. All this, of course, has placed manufactories in a very different position from that of former times.

The great incentive to economy in all cases is the increased cost of the article consumed; we therefore find, as might be naturally expected, that in places where coal is cheap and abundant it is used with but little regard to economy, and that, indeed, in some localities the men actually boast of the quantity of coal which they have contrived to burn. Under the circumstances which prevail in most of our iron-producing districts, coal being cheap, there has not been until very recently much attention given to economy in its use.

One great cause of saving fuel has been the introduction of hot instead of cold air in our blast furnaces. Mushet gives us the quantity of coal used in the Muirkirk blast furnaces in July, 1797, and shows that for the production of one ton of iron there was used 9 tons 10 cwt. 0 qr. 24lb. of coal, in the state of coke and parrot or cannel coal; at the Clyde ironworks in 1796 that 8 tons 11 cwt. 2 qr. were used. The coal for engines in the Clyde works, upwards of four tons for each ton of iron, that used for the roasting of ironstone and workmen's fires not being included. The same author makes another statement, showing that in 1840 there was some considerable attention given to economy, "so that in place of taking 5 tons of coal to a ton of iron, as was the case thirty years ago in Staffordshire, it is now produced for about 3 or 3½," and in some situations under this. In South Wales, without the aid of hot blast, the quantity of coal per ton of pig iron in the furnace had been reduced from 4 to 2½ and 2 tons. Mushet furnishes statements from which we are enabled to construct the following table:—

Names of Works.		Cold blast. Coke used per ton of iron made.	Hot blast. Coke used per ton of iron made.	Hot blast. Coal used per ton of iron.	Cold blast. Coal used per ton of iron.
		tns. cwt. qr.	tns. cwt. qr.	tns. cwt. qr.	tns. cwt. qr.
Clyde	Scotland	3 0 3	2 0 3	1 14 2	—
Dundyvan	Scotland	—	—	2 0 0	—
Milton	Derbyshire.	—	—	2 3 2	6 7 0
Milton	Derbyshire.	—	—	2 6 1	6 0 0
Codnor Park	Derbyshire.	—	—	2 3 0	—
Butterley	Derbyshire.	—	—	2 1 2	—
Alfreton	Derbyshire.	—	—	2 3 0	—

The fuel used in 1867 in Cleveland in producing 11,550 tons 6 cwt. of pig iron was as follows:—

	Tons	cwt.	qr.
Coke	16,585	0	0
Breeze	13	0	0
Coal	2,682	15	2
	19,280	15	2

This will be about 33 cwt. 1 qr. to the ton of pig iron.

Dr. Noade, in his article "Iron," in "Ure's Dictionary," published in 1860, has given the following as the quantities of coal used in the production of a ton of iron at the several works, and for the kinds of iron named:—

	Cwt.	
1. Dowlais foundry iron	50	coal.
2. Dowlais forge iron	42	„
3. Dowlais inferior forge iron	36	„
4. Hirwain foundry iron	34	coke.
5. Dundyvan foundry iron	40	coal.
6. Pontypool C. B. foundry iron	34	coke.
7. Ebbw Vale forge iron	34	coal.

In further confirmation of the importance, in point of economy, of the use of hot blast, we may quote the following from Dr. Percy's "Metallurgy," as showing the results obtained at the Clyde works in 1829:—

Coke and Cold Blast.

From January 7th to August 9th, 1829 :—

	Tons	cwt.	qr.
Average weekly make of pig iron in three furnaces	110	14	2
Average consumption of coal per ton of pig iron................	8	1	1

Coke and Hot Blast.

From January 6th to June 30, 1830 :—

Average weekly make of pig iron in three furnaces	162	2	2
Average consumption of coal per ton of pig iron	5	3	1

Coal and Hot Blast.

From January 9th to June 30, 1833 :—

Average weekly make of pig iron in four furnaces............	245	0	3
Average consumption of coal per ton of pig iron...............	2	5	1

"Hence by the application of the hot blast the same amount of fuel reduced three times as much iron, and the same amount of blast did twice as much work as previously." The following paragraphs by the same author are to the point. "During the six months of the year 1833, at the Clyde Ironworks, under the altered conditions (of using hot blast and raw coal), one ton of pig iron was made with 2 tons 5 cwt. of coal used raw, exclusive of 8 cwt. required to heat the blast. The actual consumption of coal, therefore, was 2 tons 13¼ cwt., whereas in 1829 it was 8 tons 1¼ cwt. per ton of pig iron."

Mr. Truran, writing on the same subject, says :—"In no operation connected with the manufacture of iron has there been a greater reduction made in the consumption of materials than in the coal for smelting. The rigid economy of fuel practised in several Welsh works has resulted in a saving of nearly two-thirds of the quantity formerly considered necessary. In 1791 the consumption of coal to the ton of crude iron averaged 6 tons 6 cwt. In 1821 it had diminished to 4 tons, and in 1831 to 2 tons 5 cwt., which is nearly the quantity consumed at the present day (1855)."

It is therefore evident that, many years past, there have been well-directed efforts to economise the coal used in the blast furnaces of this country; besides this, more recently a very large additional saving has been effected by collecting the gases which escape at a high temperature from the top of the blast furnace, and employing them under the boilers for the production of steam, and for many other useful purposes. It will also be found that in the processes of refining crude iron, in the boiling and in the puddling processes, constant efforts have been made and are making to increase the yield of iron and reduce the quantity of coal employed.

In relation to the blast furnaces, Mr. W. Menelaus, the manager of the Dowlais Ironworks, was the first witness examined. He entered into the question of the influence of the size and shape of the blast furnace on the economy of production, stating that, within certain limits, "the larger the furnace the better the work." He considered that "furnaces about 18ft. or 20ft. across the boshes, and 50ft. high, seem best suited to the materials of South Wales," but in the North of England "every increase in height and capacity seems to be attended with saving of fuel." It appears that one of the Dowlais furnaces for long periods made "grey foundry iron No. 3" with 25 cwt. of coal, "and frequently touched 20 cwt. Referring to the blast, he stated that the pressure of 4lb. to the inch seemed to be the most economical, although it was admitted that satisfactory experiments were wanting with higher pressures. As to the temperature of the blast, the witness said, "There can be no doubt that the higher the temperature is the less fuel will be used in the furnace. The temperature is limited, however, by the fact when very high temperatures are arrived at the cast-iron stove-pipes are melted, and this seems to put a practical limit to increased economy until some plan is devised for heating the blast in chambers of fire-resisting material which will bear a much higher temperature than cast-iron."

Mr. I. Lowthian Bell gave much valuable evidence on this point. Referring to the question of the size of the blast furnace and its relation to the economy of fuel, he stated, that in 1863 no blast furnace in the north exceeded 6,000ft. in cubic capacity, but that now, 1860, "We have them ranging in size to 35,000 cubic feet, or five and a half times larger that they were five years since." This enlargement is thought to have proceeded an economy in fuel to the extent of 20 per cent. We gather from Mr. Bell's evidence that he believes the limits of size, in relation to effective economy, to have been exceeded in the largest furnaces—those having a height of 102ft. This witness is led from his large experience and careful observations to believe that furnaces of 15,000ft. capacity are the most economical. He supposes that the more recent large furnaces have been raised to an unnecessary height. At the same time he believes that by increasing the temperature of the blast the results would be materially affected. At present, with the Cleveland ironstone, the consumption of coke in the furnaces of the northern counties is about 23 cwt., but it is admitted that this quantity will probably undergo some, but not a large reduction.

On the same question Capt. A. Noble furnished the results of some carefully conducted experiments to which the reader is especially referred. Having a furnace 75ft. in height, it is stated that about 25 cwt. of coke is consumed per ton of iron made. Capt. A. Noble replies to a question as to the advantages of an increase in height, that he does not think an increase in the height of the furnace would effect a saving of more than 1 cwt. He holds that the only advantage to be gained by increased height in the furnaces will be that the gases escaping from the contents of the furnaces (waste gases) will be robbed of some of their heat, which heat will be utilised in the upper portion of the furnace.

Utilisation of Waste Gases for Heating, Blast, &c., &c.

A careful examination of the gaseous mixture produced by the materials, from ore, limestone, and coal, in the blast furnace, and escaping from it, was made by M. Bunsen in 1845.

The results of his inquiry were as follows :—

	By weight	By the combustion of 100 of the furnace gases there are generated units of heat.
Nitrogen	59,552	0000
Carbonic acid	12,765	0000
Carbonic oxide......................	26,006	6·5067
Light carburetted hydrogen ...	1397	1·8826
Hydrogen	0078	2704
Condensed hydrocarbon (olifiant gas)	0108	1331
Sulphuretted hydrogen	0053	238
Ammonia	0054	208
	100,000	8·8374

The unit must be understood to mean the amount of heat necessary to raise one kilogramme = 2204lb. = 15,432 grains of water from 0 cent. to 1 deg. cent.

We have it in the evidence of Capt. Noble that in the production of 50 tons of pig iron and 90 tons of slag from the blast furnace, of 57 tons of coke used, about two tons entered into combination with the iron, and that the remaining 55 tons passed out of the mouth of the furnace in the state of carbonic oxide and carbonic acid (16 tons of carbon forming about 60 tons of carbonic acid and about 90 tons of carbonic oxide), mixed with about 250 tons of nitrogen derived from the 325 tons of atmospheric air, which had been blown, heated to nearly 1000 deg. Fah., into the furnace. The 16 tons of carbon (coke) which are burnt to carbonic acid give rise to about 519,680,000, and the 39 tons burnt to carbonic oxide give rise to about 384,384,000 British units of heat. The heated air blown into the furnace would give, to be added to the foregoing, 160,000,000 units of heat = 1,064,064,000 units of heat. The reduction of the 68 tons of iron ore to the metallic state uses 353,222,000 units of this heat. The 50 tons of pig iron produced is calculated to absorb about 66,000,000 units of heat, while the 90 tons of slag employ 199,800,000 units. The waste gases escaping absorb about 320,000,000 units of heat. Thus we account for above 938 millions of the units of heat produced, leaving about 10 per cent. of the heat unaccounted for, which we may consider to be lost by the imperfections of our arrangements. We have here the striking fact that nearly two-thirds of the total quantity of heat produced in the blast furnace escapes from the mouth of the furnace. To what extent this heat can be utilised is a very important problem, which has been to some extent answered. Mr. James Palmer Budd, of the Ystalyfera Ironworks near Swansea, at a meeting of the British Association in that town in 1848, read a paper "On the Advantageous Use made of the Gaseous Escape from the Blast Furnaces at the Ystalyfera Ironworks," which was ordered to be printed entire in the report.

Looking to the enormous quantity of cold air which was driven through the furnace to produce a temperature sufficiently high to smelt the ore, the advantages of heating that air employed to quicken the combustion of the fuel in the blast furnace, and consequently of saving and utilising the heat which was required to bring up the temperature of the blast to that of the furnace, became obvious, and in 1828 Mr. James Beaumont Neilson, of Glasgow, suggested the use of the hot blast in smelting iron, which as we have already stated, effected a large saving.

The first idea, therefore, for utilising the heat of the gases and vapours escaping from the funnel head of the blast furnace was to conduct this hot air through the hot-air stove, and use it instead of coal for heating the air which was to be blown into the furnace. Mr. J. Palmer Budd states that the three stoves employed to heat the blast for the anthracite furnaces at Ystalyfera consumed 35 tons of coal a week, and required the attendance of two men. He constructed his stoves so that

a portion of the hot gaseous escape from the top of the furnace was drawn through them, this being about "one-sixth of the quantity passing off the funnel head." These gases entered the stove with a temperature of about 1,800° Fah., and leave it about 800°. The temperature required for the blast being only 600°, the passage of the heated gases alone, without an access of air, supplied more than the heat required—the gases, it must be remembered, escaping at such a temperature, that if air was admitted to them they would at once burst into combustion—and thus form another source of heat which has been utilised in many of our ironworks in raising steam. We have it in evidence that the higher the temperature of the blast the less fuel will be required in the furnace, and that although, where coke is used, there may be less of the heated gases escaping, "that in every case the waste gases from the blast furnace would be found sufficient to heat the blast, and produce all the steam required for the blast furnaces," and that in addition they might be used to "calcine the native mineral." Notwithstanding the various arrangements which have been made to employ the heat of the waste gases, "we all allow the gases to escape at too high a temperature," is the remark of another witness. Here, therefore, is a matter which still demands the attention equally of the man of science and experience. There is one point, however, to which attention was drawn by Sir William Armstrong during the examination of Captain Noble, which appears to bring the question of hot and cold blasts within a much more limited compass than it has usually been supposed to occupy. By increasing the temperature of the blast from 60° to 1,000°, 7 cwt. of coke is saved in the furnace. Consequently, as it respects the question of economy of fuel, and that only, we have to consider the cost, in every particular, of heating the blast. Probably the regenerative process, using the heat of the waste gases, may place this consideration entirely beyond the position alluded to. The result of the experience of many years has been that a few only of our blast furnaces (Lowmoor, Bowling, and a few others) continue to use cold air for blast. The application of hot air for blast has greatly reduced the consumption of coal. The adoption in nearly all new furnaces of the arrangements for using the "waste gases," and the adaptation of a considerable number of old ones to the conditions necessary for utilising the heat from this source, has again been a source of an additional economy. All the evidence collected from the witnesses examined, the communications received from and interviews held with iron-masters, go to prove that in one way and another a saving of not less than 20 per cent. has been effected in the smelting of iron during the last ten years, and all the indications are that yet increased economy will be effected in the future. In the evidence of Mr. Menelans it is stated that it is extremely desirable to increase the temperature of the blast beyond that which can be obtained with cast iron stove pipes, and that any practical scheme for freeing the blast entirely from dust would be a great improvement.

An attempt to arrive at this desired end, which appears to have been to a great extent successful, has been recently made by Mr. Thomas Whitwell, of the Thornaby Ironworks, Cleveland, who has introduced at his own works and at Consett the "patent fire-brick stoves." Judging from the information furnished by Mr. Whitwell to the committee, a large economy has been effected by these stoves, the arrangements of which are such that the dust which accumulates can readily be removed. Mr. E. A. Cowper, in a communication, and subsequently in evidence given before us, drew attention to some hot-blast furnaces on the regenerative system which are the subject of a patent, and which have been in use at a few ironworks for some years. It is stated by Mr. Cowper, and this statement is confirmed by Mr. Cochrane, that a temperature is produced in these stoves of 1150 deg. Fah., and that a saving equal to 5 per cent. in the furnace is produced. There have been some other plans proposed for heating the blast with economy, but the regenerative system appears to be that which must be the most economical. At the same time there is clearly some risk that in drawing off the gases from the funnel head too rapidly we may increase the quantity of fuel required for the smelting of the iron in the blast furnaces. Sir William Armstrong, Capt. Noble, and Dr. Fairbairn cautiously point to the necessity of attending to the preservation of the balance of action.

The following results obtained at Glawitz, in Silesia, and communicated to the committee, are of interest, as showing that similar economical results follow the application of the principles we have been examining on the continent. Two blast furnaces.

Cold Blast.

(1)	Boilers for blast engines fired with coal, annual cost ...	£3,250
(2)	Ditto fired with waste gas	1,800

Blast Heated to 312 Degrees.

(3)	Boilers and stoves fired with coal	4.800
(4)	Ditto with gas	3,690

The daily volume of blast in either case is 20,368,000 cubic feet, the cost per million cubic feet therefore is in the different cases—

	s.	d.
1	9	2
2	4	11
3	13	0
4	10	0

Mills and Forges, Furnaces, &c.

Mr. Menelaus, in his evidence, informs us that at Dowlais 4 cwt. of large and 13 cwt. small coal is used in producing a ton of puddled bars, and that a further quantity of 3 cwt. of coal is used to produce steam for hammering and rolling the puddled iron, although the furnace gasos have been carried to the forges in some cases; the average quantity of coal used to produce a ton of puddled bar in South Wales being from 17 cwt. to 20 cwt. This witness considers that as the heated gases leave the puddling and balling furnaces at nearly the temperature of melting iron, the waste heat of the puddling and mill furnaces "is amply sufficient to produce all the steam required, and no coal is, therefore, necessary to produce steam in forges and mills." "For the production of steam in forges and mills in South Wales there is used over a quarter of a million tons of coal yearly which might all be saved." By the application of the fan blast the ironmaster has been enabled to use small coal almost entirely. Formerly the coal was hand picked, and no small was used; now the "through and through" coal is employed, thus utilising fuel which was formerly lost. The actual results at which we have arrived appear to be that for every 100 deg. of increased temperature given to the blast for the iron furnace we save 1 cwt. of coal; that by using the heated gases escaping we may save all the coal necessary for heating the blast, and have some residuary heat for raising steam; that the waste heat of puddling and balling furnaces may be in like manner utilised with great economy.

(To be continued.)

REVIEWS AND NOTICES OF NEW BOOKS.

Report of the U.S. Commissioner of Patents for the year 1868. Washington.

The number of patents taken out in America during one year is perfectly marvellous. We have just received four bulky octavo volumes, containing minature sketches and short abstracts of the patents issued from the Patent Office at Washington during the year 1868, and we find that they begin with No. 72,959, and end with No. 85,502, making 12,543 patents for one year, or between three and four times as many as those granted in England. These volumes, like those of former years, are exceedingly useful for reference to inventors or mechanics, who wish to pick up a "wrinkle," as some new, if not valuable design, may be discovered upon almost every conceivable mechanical arrangement.

OBITUARY.

THE LATE MR. THOMAS PILGRIM.

We have to record the death of Mr. Thomas Pilgrim, whose name has been for many years past associated with that of Mr. F. P. Smith, in connection with the development of screw propulsion. Mr. Pilgrim was born in the year 1800, and died on the 6th ult. at Plumstead, Kent. In 1836 a small steam vessel, of 10 tons burthen, was built and fitted with a Smith screw, and engineered by Mr. Pilgrim, put to sea in 1837, visiting Dover, Folkestone, &c., in heavy weather thus demonstrating that the screw would act in rough as well as in smooth water. In the following year the *Archimedes*, a vessel of 237 tons burthen and 80 horse power, was built by Messrs. Rennie. This ship is celebrated in the history of steam navigation as being the first vessel ever sent to sea propelled by a screw,— and to her Mr. Pilgrim was appointed engineer-in-chief. Mr. Pilgrim was also the inventor of an apparatus for superheating steam, which consisted of a series of arched pipes placed in the boiler furnace, and through which the steam was conducted on its way to the cylinders. The apparatus was applied, about the year 1860, to H.M. steam-tug *Bustler*, also upon several of the steamboats running between London and Woolwich, and several vessels in the mercantile marine, but does not appear to have been used since that time.

NOTES AND NOVELTIES.

MISCELLANEOUS.

The nine hours principle was conceded on the 16th ult. to the workmen in the Middleton Ironworks at Hartlepool, and a mass meeting was held upon the Town-moor in the afternoon, at which it was resolved to present the firm with a complimentary address.

The *Boston Transcript* says that the Commissioners upon the reduction of Bunker-hill have made their report to the city Government of Charlestown. The total cost of the undertaking is estimated at 3,271,771 dols. From this should be deducted the value of Mill Pond lands and Mystic River flats to be filled in, 1,726,178 dols., which will leave the net cost 1,545,644 dols. The street opposite St. Frances de Sales church is to be lowered 46ft., and other points in decreasing proportion. The lowering of the Catholic Church, and the removal of the adjoining cemetery, which contains nearly 8,000 corpses, are among the most formidable obstacles of the enterprise. The district proposed to be reduced contains about 45 acres. The area of the Mill Pond lands to be filled is 1,549,600 square feet; the flats adjoining, 1,992,521 square feet. A marginal street, 3,300ft. in length and 60ft. in width, with 15 lateral streets, each 540ft. in length are to be laid out upon the new territory. The area of flats in Mystic River to be filled in is 2,851,187 square feet. The number of buildings in the district which will required to be lowered is 473. The contemplated improvement will add about 150 acres to the territorial limits of Charlestown. Bunker-hill has already been lowered 14ft., and should this plan be consummated it will have been lowered 60ft. from its original height at the summit. The Commissioners recommend that the project be submitted to a vote of the citizens.

We understand that, Mr. Jamieson, a member of the firm of Messrs. Randolph, Elder and Co. met a deputation from the ship carpenters at present on strike, on the 17th ult., and, on behalf of the masters, offered to concede the 6d. per hour demanded by the men. We presume, therefore, that the dispute may be considered at an end.

An important work of hydraulic engineering has been recently commenced with the view of utilising the fall of the Rhone at Bellegarde, near Geneva. By driving a tunnel about 600 yards long about a third of the water will be diverted from the river, and delivered into the neighbouring valley of the Valseriane, with an available fall of 44ft., the supply being estimated at rather more than 2,000 cubic feet per second at the period of lowest water. This corresponds to 10,000-h.p., or as much as that which has created Lowell the Manchester of America. The promoters of the enterprise point out that the position is admirably situated for the erection of cotton and woollen mills, as, in addition to furnishing power, the water is of exceptional purity.

Gas will shortly be introduced in the principal commercial town of Japan namely, Yokohama—and in part of the city of Yedo—the seat of the Mikado's Government. The contract for the construction of the works required in this undertaking has been negotiated through the medium of Messrs. Miller Brothers, Glasgow, and has been intrusted by them to Messrs. Robert Laidlaw and Son, gas engineers, of that city. The first portion of the works, comprising about one-fourth of the entire undertaking, is now ready. The plans have been prepared by a French engineer, and the erection and management of the works will be conducted under his personal superintendence, while the labour will be performed by native Japanese workmen. The company is named the Yokohama and Tokio Gas Company.

A Franco-German Company has been formed under the title of the Rhine Steel Works Company, and has erected some vast establishments for the production of Bessemer cast steel. Tools have also been provided for the transformation of the ingots into rails, tyres, axles, rings for cannons, &c. The greater part of the works are now in activity, and the whole will be in regular operation with the close of the current year.

A new torpedo boat is to be built at the Washington Navy-yard, measuring 175ft. in length by 45ft. beam. Her hull will be of iron, 3ft. out of water. The exposed part will be armour-plated with 5in. iron backed with wood. She will be propelled by two screws, and her engines are expected to drive her fourteen knots per hour, minimum speed. She will have for fair weather two masts, schooner-rigged. The torpedo will contain 100lb. of powder, attached to an iron beam which will protrude from the bow below the water-line. This beam will be 25ft. long, and so adjusted as to be forced out by hand from a water-tight compartment through packing. It will be worked by hand instead of steam, because any unexpected obstruction can be more easily detected that way than otherwise. It is intended, when orders are given to that effect, that the torpedo boat shall make straight, under a full head of steam, for an enemy's ship, run well under her, and explode the torpedo by electricity, the beam being withdrawn at the same time. The boat will be of comparatively light draught, requiring 11½ft. of water.

NAVAL ENGINEERING.

Mr. Dion, of New York, proposes to place on board vessels an apparatus which will give an alarm when the vessel is in the vicinity of icebergs. This apparatus, placed at the bottom of the hold, is such that, when the keel is in very cold waters, it sounds an alarm; thus a signal is given of the vicinity of icebergs, which cool the water to a great distance around them. This instrument serves also as a thermometer, and shows at all times the temperature of the water under the ship.

MILITARY ENGINEERING.

Great activity continues to be displayed in the production of artillery in France. In the Loire district the cannon foundries are very busily employed. Some breech-loading cannon, upon a system introduced by Colonel Reffye, have been successfully submitted to very severe tests. Some of the cannon made of late have a range of 3¼ miles.

TELEGRAPHIC ENGINEERING.

A statement, which has obtained currency, of a closer amalgamation of the Anglo and French Atlantic Telegraph Companies is said to be entirely without foundation. The subject has been mooted by some influential shareholders; but the difficulty of a combination of the stock and shares, with no adequate gain to the shareholders, precludes for the time any such arrangement. The perfect harmony which exists in the present system is considered also to render it unnecessary.

STEAMSHIPPING.

Messrs. Tod and M'Gregor, the eminent shipbuilders in Glasgow, have contracted with the new Larne and Stranraer Steam-Packet Company for a first-class paddle steamer for the short sea passage between these ports. It is expected the vessel will be ready to commence the service not later than the 1st day of May next; and the engines being of great power, the passage between the two ports will be made on the average of two and a half hours.

SHIPBUILDING.

The Royal paddle yacht *Osborne*, built at Pembroke dockyard for the service of the Prince and Princess of Wales, lying in dock at Portsmouth, is ordered to have the two-inch thickness of planking with which her hull is now sheathed doubled over by another thickness of planking, this time of teak, and three inches in thickness. The cost of this work in labour and material will be between £6,000 and £7,000. It is also anticipated that the yacht's upper deck will have to be re-laid. The work has been apparently done with a view of economising as far as possible, so as to turn out a vessel of the kind at a comparatively low expenditure from Pembroke, as compared with other yards. This was done so effectually that the unearthly creaking and groaning of the yacht's frame on her steaming round from Pembroke to Portsmouth is said to have told the yacht's tale of distress plainly enough. After her arrival at Portsmouth, and while lying in the smooth water of the steam basin, she leaked very seriously, and then came the order, reluctantly given, to strip off the vessel's copper and examine the bottom planking underneath. The cause then became plain enough in the insufficient thickness of the planking. As the cost of taking off the copper sheathing alone, allowing for the difference in value between the copper sheets taking off and the new ones to go on, must have been upwards of £1,000, this, with the cost for doubling the bottom planking and the re-laying of the decks will make the *Osborne* a rather expensive, instead of being a wonderfully cheap vessel in her construction, as was intended. It is understood that a considerable saving has been effected in building the vessel in the way she has been upon the sum taken for her construction in the Navy Estimates.

LAUNCHES.

On the 16th ult. Messrs. John Elder and Co. launched from their shipbuilding yard, at Fairfield, Govan, an iron screw steamship of 3,850 gross tonnage, and 550 h.p. nominal, for the Pacific Steam Navigation Company of Liverpool. The vessel has been designed and constructed for that company's fortnightly service between Liverpool and Valparaiso, *via* the Straits of Magellan, and is of the following dimensions:—Length between perpendiculars, 370ft.; breadth, 41ft.; depth moulded to spar deck, 36ft. 9in. In the equipment of the ship the latest improvements have been introduced, her internal arrangements, state rooms, saloon, etc., being fitted up and furnished in the highest style of elegance and comfort, having accommodation for 140 first-class, 40 second-class, and 800 third-class passengers if required. The engines, which are being supplied by the same firm, are upon their compound principle, with all recent improvements. The ceremony of naming the *Cuzco* was gracefully performed by Miss Barnes.

The new twin-screw iron armour-clad turret ship *Gorgon*, built for Her Majesty's Government by Messrs. Palmer and Co., of Jarrow-on-Tyne, was launched from the yard of that firm on the 14th ult. The dimensions, &c., of the *Gorgon* are as follows:—Length between perpendiculars, 225ft.; length of keel for tonnage, 195ft. 7⅝in.; breadth extreme and for tonnage, 45ft.; depth in hold, 19ft. 2in.; burden in tons, No. 2,107 23—94. The *Gorgon* has two turrets, constructed to carry two guns of 18 tons each. The turrets are protected by an armour-plated breastwork 116ft. in extent, 10in. and 9in. thick. The breastwork is raised seven feet above the deck. Above the breastwork there is a flying deck of light iron framework from which to direct the vessel. The upper deck is formed of two thicknesses of three-quarter inch plating, covered by teak planking eight inches thick. The sides of the ship are covered by two strakes of armour—the upper strake being eight inches thick and the lower strake six inches. Behind the armour plating on the ship's sides is teaking nine and eleven inches thick, and immediately behind this are two thicknesses of ⅝ths plating. The total weight of the armour on the ship is 860 tons. There will be two engines, each of 250-h.p., made by Messrs. Ravenhill, Hodgin, and Co., of London. There are two screws, and the propellers are four-bladed. The internal fittings are of the usual description.

On September the 30th, from the shipbuilding yard of Messrs. H. Murray and Co. Port-Glasgow, was launched a finely-modelled screw-steamer, of the following dimensions, viz.:—Length of keel, 155ft.; breadth, 21ft.; depth of hold, 11ft. Classed 90 A at Lloyd's. As the vessel left the ways she was gracefully named *Maria* by Miss Rowan, daughter of Mr. D. Rowan. The vessel was towed to Glasgow to receive her machinery, which is to be supplied by Mr. D. Rowan of Elliot Street. The engines will be constructed on the compound principle, the cylinders being 19in. and 33in. by 24in stroke. The steamer is the property of Captain Nolan, owner of the late yacht. *Phasma*.

On the 3th ult. Messrs. Wingate launched from their building at Whiteinch a twin-screw dredger, for Barrow-in-Furness, built to the order of Messrs. M' Clean and Stileman, C.E., London. This dredger is a duplicate of the machine built several months ago by Messrs. Wingate to the same order—500 tons b.m., 70 h.p. engines, adapted for dredging to 30ft., and raising upwards of 350 tons per hour.

On the 14th ult. there was launched by the London and Glasgow Engineering and Iron Shipbuilding Company for Messrs. Allan C. Gow and Co. of that city, a handsomely modelled screw-steamer of about 2,200 tons gross register, built to class 100 A, the highest class in Lloyd's books. Her dimensions are—Length; 330ft.; beam, 34ft.; and total depth, 24ft. 6in. As the vessel left the ways she was in the usual time-honoured manner, gracefully named the *Glenroy* by Miss Reid, of Hillock House, Govan. Immediately after the launch, the *Glenroy* was towed up to Glasgow, where she will be fitted by her builders with compound surface condensing engines of 250 h.p. nominal, combining all the most recent improvements in this description of engines. The *Glenroy* is the second vessel built by the company for Messrs. Gow and Co., specially for their East India trade, *via* the Suez Canal, and is a sister to the *Rydal Hall*, completed and delivered in August last for Mr. Robert Alexander, of Liverpool, and which has just completed her first run out to Colombo in 27½ days from Liverpool.

The *Olympic*, the fifth of the White Star line of Liverpool and New York packets, was launched from the shipbuilding yard of Harland and Wolff, Belfast, on the 17th ult Three other vessels are about to be put upon the slips by the above firm each of which is to be 480ft. long.

On the 19th ult. Messrs. Henderson, Coulborn and Co., successfully launched from their building yard at Renfrew a screw steamer, named the *Knud*, 1,400 tons burden, for a Copenhagen company. This vessel will be fitted with the builder's compound engines of 150 h.p., nominal. The christening ceremony was gracefully performed by Mrs Hansen, wife of the commander of the steamer. The *Knud* is a duplicate of the steamer *Gorm*, which the same builders completed and despatched last week.

On the 3rd ult. Messrs. Cunliffe and Dunlop launched from their engineering and shipbuilding works at Port Glasgow, the *Arthur*, an iron paddle steamer, 150ft. long, 22ft. beam, and 60 h.p. nominal. She has been built to the order of Messrs. Gregor Turnbull and Co., of Glasgow, and is intended for the colonial mail service at Trinidad.

TRIAL TRIPS.

The *Vigilant*, paddle despatch-vessel, 835 tons, 250-h.p., in charge of Capt. Charles Fellowes, C.B., and Staff of the Steam Reserve, and having on board Mr. Bardin, C.B., and Mr. R. Nicoll (Chief Inspector of Machinery Afloat), made a highly satisfactory trial of her speed in the offing at Plymouth on the 9th ult. Since the trial of this vessel on the 5th of August, when sufficient water could not be obtained through the injection pipe, an additional pipe has been fitted, which gives a freer entrance to the water. The vessel's draught was—forward, 9ft. 11in.; aft, 10ft. 2in.; the wind east, force 3 to 4; the sea smooth; barometer, 30·19; thermometer, 64. Six runs over the measured mile were made at full boiler power, with the following result:—Mean speed, 14·786 knots per hour; mean revolutions, 35·17 per minute; mean steam pressure, 29·41lb.; mean vacuum

24·75in., giving an approximate indicated power of 1,814 horse, or over seven times the nominal H.P. The mean of four runs at half-boiler power gave a speed of 12·462 knots, with revolutions, 29·05 per minute; steam pressure, 23lb.; vacuum, 26·5in. On the 5th of August the speed realized at full power was only 14·11 knots, and at half power 11·5 knots; and on the 16th of August, at full power, 14·324 knots; half-power, 12·231 knots. It will thus be seen that the *Vigilant* attained on the present trial a greater speed, both at full and half power, than she did on either of the previous trials.

RAILWAYS.

WHILE people are talking of a railway to India direct, to accomplish the passage from London to Calcutta in five days, the Viceroy of Egypt has actually commenced one of the most gigantic undertakings ever attempted in his territory—that of connecting Upper and Lower Egypt by rail. At the terminal point of all ancient and modern conquest, where the mighty Persian and Roman invaders found the desert an impassable barrier, the Khedive, assisted by an army of English engineers and navvies, will, unless stopped by the jealousy of the Sultan, drive an iron road and a team of iron horses, not only to the very confines of Nubia, but into the heart of Africa, opening up new fields for commerce, and perhaps bringing home Livingstone first-class. Twenty of the engineers for the above undertaking passed through Malta a few days ago on their way, and will be followed by the remainder of the staff in a short time. When it is considered that the line, commencing at the Second Cataract, is to be 600 miles long, some idea may be formed of the amount of labour required to complete the work.

PASSENGERS through the Midland districts have long regarded the Midland Company's station at Gloucester as utterly unfit for so large and growing a city, and the Town Council have unanimously resolved to present a petition to the Midland Company, reminding them that the place was a wooden structure temporarily put up thirty years ago for the use of the Gloucester and Birmingham line, yet that, despite the subsequent development of the railway system, the opening of a direct main line of communication through Gloucester between the north and the west of England, and the fact that the business of the port had since greatly increased, this wooden shed, with additions of the same character, had still served as a railway station for one of the most important towns on the Midland system. Therefore, the memorialists asked that a proper station should now be provided and that there should also be a ticket platform near the park. The Mayor said that the chairman of the Midland Company, Mr. Price, M.P. for the city, had assured him that he and his co-directors had already voted money for the purpose, and were willing to build in Gloucester a handsome station as soon as due terms had been made with the Great Western Company. "For," said Mr. Price, "I feel that the present station is a disgrace to Gloucester." The Mayor declared that during the late rains the water had dripped through the station roof as through a colander. There seemed a further feeling that the Great Western and the Midland Companies might unite in the scheme, and thus that there might be the present union of the stations, with due convenience and beauty; and a short memorial to the Great Western was also agreed upon.

AN American paper says:—"The island of Newfoundland has caught the railroad fever, and has advanced an idea which, if carried out, will shorten still more the voyage between the continents. It is proposed to construct a line of railway from St. John across the island to St. George's Bay, a distance of 158 miles. Passengers from Europe, instead of landing at Halifax, would leave at St. John, cross the island by rail, and take a steam ferry for the western port of Shippegan harbour, Bay of Chaleur, where they would join the Intercolonial Railway, which, when completed will connect with the great network of railroads throughout the United States and Dominion. This would constitute the shortest and safest route for passengers and mails between Europe and America. The dangers arising from fogs, currents, and reefs along the thousand miles of American coast, on which so many vessels meet their doom, would be avoided. After a run of four or five days passengers would land at St. John, step into a railway carriage, and enjoy the pleasure of being whisked across Newfoundland in eight hours; and, in 24 hours, would find themselves at Shippegan, whence a branch of the Intercolonial Railway would forward them to any part of the States of Canada in a few hours. The distinguished engineer, Mr. Sandford Fleming, has been the first to suggest this route and to stamp it with his high approval. He is of the opinion that it would prove a remunerative undertaking, and would attract to it a large portion of the passenger traffic and mail matter now passing between the two continents. The near future, he considers, will see it carried out; and he believes that a daily line of steamers across the ocean would find ample employment. Mails and passengers from London would reach New York in seven days by this route, Chicago in eight days, and San Francisco (*viâ* Chicago) in 12 days. When the Canadian Pacific line is constructed, this link is its natural completion, and would make St. John, Newfoundland, its eastern terminus. A line of steamers from a port in British Columbia to China and Japan, and another line to Australia, would supply channels by which the commerce of Asia and Australasia would roach Europe across Newfoundland."

THE San Paulo Railway, a somewhat important Anglo-Brazilian line, which is 86½ miles in length, earned in 1870, £199,258; and the working expenses having been £78,560, a net profit of £120,698 remained. The proportion of the working expenses to the traffic receipts last year will be seen to have been only 39·42 per cent. The San Paulo line, deducting the sierra inclines, consists of two distinct lines below and above the sierra, 13½ miles and 63 miles in length respectively, and as distinct lines more costly to work than if they were continuous. On the above sierra line the gradients are often necessarily severe, as there is no leading valley to follow; there is a length of 13¾ miles of gradients varying from 1 in 40 to 1 in 60.

IT is affirmed that the Nizam's Railway from Goolburga on the Great Indian Peninsula system to Hyderabad will shortly be put in hand. The estimates and plans are being altered from the broad to the metre gauge. The East Indian Railway, which had been damaged by floods between Umballa and Saharunpore and Umballa and Kartarpur, has been again made available for traffic.

THE directors of the Great Western Company have reduced the time of the men employed in the locomotive carriage works, to the number of 3,000, one hour per week. They now leave work at one o'clock on Saturday instead of two o'clock as formerly, making the week's work 57½ hours instead of 58½.

THE new station of the New York Central, Hudson River, Hudson and New Haven Railways—the "Vanderbilt Combination"—at Fourth Avenue and Forty-second-street, New York city, has been opened for the use of the travelling public. It is said to be the largest railway station in the world.

APPLIED CHEMISTRY.

A SIMPLE METHOD O ENAMELLING CAMEO PICTURES.—Ordin ry well polished glass plates are coated with normal co lodion, and when the film has set perfectly, but has not become dry, the pictures, which have previously been trimmed and finished, are dipped into alcohol, and applied without delay to the plates. The prints are pressed and rubbed down with smooth writing paper, and the operation of mounting is proceeded with as soon as the backs of the pictures have become white, or, in other words, as soon as the alcohol has again evaporated. The cardboard should be allowed to remain in water for at least half an hour previously to its being employed for mounting. The more rapidly the pictures are applied and pressed upon the collodion surface, the more beautiful wil be the finished result.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	From s.	From d.	To £	To s.	To d.
COPPER.						
Best selected, per ton	77	0	0	78	0	0
Tough cake and tile do.	74	0	0	76	0	0
Sheathing and sheets do.	77	0	0	78	0	0
Bolts do.	79	0	0	80	0	0
Bottoms do.	81	0	0	83	0	0
Old do.	60	0	0	"	"	"
Burra Burra do.	76	0	0	77	0	0
Wire, per lb.	0	0	9¾	0	0	10
Tubes do.	0	0	10½	0	0	10¾
BRASS.						
Sheets, per lb.	0	0	8	0	0	8¾
Wire do.	0	0	8	"	"	"
Tubes do.	0	0	8	0	0	10½
Yellow metal sheathing do.	0	0	6¾	0	0	7¼
Sheets do.	0	0	6½	0	0	6⅝
SPELTER.						
Foreign on the spot, per ton.	18	15	0	19	5	0
Do. to arrive.	18	15	0	"	"	"
ZINC.						
In sheets, per ton	24	0	0	24	10	0
TIN.						
English blocks, per ton.	141	0	0	"	"	"
Do. bars (in barrels) do.	142	0	0	"	"	"
Do. refined do.	144	0	0	"	"	"
Banca do.	137	0	0	"	"	"
Straits do.	135	0	0	136	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	9	6	1	10	6
IX. do. 1st quality do.	1	15	6	1	16	6
IC. do. 2nd quality do.	1	7	6	1	8	0
IX. do. 2nd quality do.	1	13	6	1	14	0
IC. Coke do.	1	5	0	1	7	0
IX. do. do.	1	11	0	1	13	0
Canada plates, per ton	13	10	0	15	0	0
Do. at works do.	13	10	0	14	0	0
IRON.						
Bars, Welsh, in London, per ton	8	2	6	8	10	0
Do. to arrive do.	7	15	0	8	0	0
N lrods do.	8	0	0	"	"	"
D Stafford in London do.	9	0	0	"	"	"
Bars do. do.	9	5	0	9	10	0
Hoops do. do.	10	0	0	"	"	"
Bars do. at works do.	8	10	0	"	"	"
Hoops do. do.	9	2	6	"	"	"
Sheets, single, do.	10	15	0	11	0	0
Pig No. 1 in Wales do.	4	10	0	5	10	0
Refined metal do.	4	10	0	5	10	0
Bars, common, do.	7	2	6	7	5	0
Do. mrch. Tyne or Tees do.	7	15	0	8	0	0
Do. railway, in Wales, do.	7	0	0	7	15	0
Do. Swedish in London do.	11	0	0	"	"	"
To arrive do.	10	15	0	11	0	0
Pig No. 1 in Clyde do.	3	3	0	3	10	0
Do. f.o.b. Tyne or Tees do.	"	"	"	"	"	"
Do. Nos. 3 and 4 f.o.b. do.	"			"	"	"
Railway chairs do.	3	15	0	4	0	0
Do. spikes do.	12	0	0	12	10	0
Indian charcoal pigs in London do.	6	10	0	7	0	0
STEEL.						
Swedish in kegs (rolled), per ton	13	0	0	14	0	0
Do. (hammered) do.	13	10	0	"	"	"
Do. in faggots do.	15	0	0	16	0	0
English spring do.	17	0	0	23	0	0
QUICKSILVER, per bottle	10	0	0	"	"	"
LEAD.						
English pig, common, per ton	18	0	0	18	2	6
Ditto L.B. do.	18	2	6	18	5	0
Do. W.B. do.	20	5	0	"	"	"
Do. sheet, do.	18	15	0	19	0	0
Do. red lead do.	20	10	0	21	0	0
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	20	10	0	"	"	"
Spanish do.	17	10	0			"

* At the works 1s. to 1s. 6d. per box less.

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

DATED SEPTEMBER 9th, 1871.

2385 J. Livesey—Asphalte
2386 J. and S. W. Varley—Cleaning silk
2387 H. Bayliss—Nipple wrenches
2388 E. Brasier—Breaking sugar cane

DATED SEPTEMBER 11th, 1871.

2389 W. Weldon—Potash
2390 T. Simpson—Brushes
2391 R. Johnson—Asphalte
2392 H. Stead—Musical instrument
2393 A. V. Newton—Preventing oxidation of iron
2394 M. Mirfield and J. Scott—Extracting grease
2395 T. J. Smith—Obtaining motive power

DATED SEPTEMBER 12th, 1871.

2396 J. Hall—Firearms
2397 J. T. Griffin—Lawn mowers
2398 R. Long—Latches
2399 T. Scruton—Coffins
2400 J. Pearson and R. Rumney—Mules for spinning
2401 W. H. Barlow—Pumps
2402 H. Bunning and J. Chapman—Street pavements
2403 W. R. Lake—Manufacture of iron
2404 C. Minasi—Closing necked vessels
2405 R. F. Miller—Omnibuses
2406 W. R. Lake—Press for compressing cotton
2407 A. Bresson—Vehicle, &c.
2408 G. Haseltine—Indicating weight

DATED SEPTEMBER 13th, 1871.

2409 R. W. Thomson—Guiding steamers
2410 A. St. G. Cuff—Looking glasses
2411 H. C. Bell—Securing rails
2412 C. F. Clark—Box irons
2413 M. Heury—Desilvering lead

DATED SEPTEMBER 14th, 1871.

2414 A. M. Clark—Spinning machines
2415 B. D. Healey—Casting pits
2416 C. D. Abel—Screw propellers
2417 W. R. Lake—Stuffing boxes
2418 J. L. Clark and J. Muirhead—Telegraph instruments
2419 H. D. Bottrill—Looms
2420 G. Webb—Excavating below water
2421 J. E. Wood—A new paint
2422 J. Bower—Refining iron
2423 J. Harrington—Imitation leather
2424 J. Howard—Ploughs
2425 W. E. Newton—Furnaces
2426 W. R. Lake—Electro-magnetic apparatus

DATED SEPTEMBER 15th, 1871.

2427 J. Platt—Distilling columns
2428 W. H. Westo and M. Pinder—Waste pipes
2429 J. Gillespie—Fire clay
2430 E. C. Nicholson and A. P. Price—Gun cotton
2431 J. Gillingham—Couches
2432 D. Fryer and R. Steers—Portable vice
2433 J. G. Sowerby—Ornamenting glass
2434 T. Sampson—Piece dyeing
2435 B. Hunt—Telegraph instruments
2436 G. Westinghouse—Working brakes
2437 H. D. Furness—Lubricating
2438 W. Prosser—Conducting fluids
2439 W. R. Lake—Electro-magnetic engine

DATED SEPTEMBER 16th, 1871.

2440 G. T. Chapman—Hard covering, &c.
2441 A. Veillet and C. Verny—Signals
2442 J. Wilde and H. Sinclair—Level indicator
2443 C. Naylor—Commodes
2444 J. Gowans—Tramways
2445 J. Murdoch—Washing clothes
2446 D. B. Peebles—Gas regulators
2447 W. Brooke—Bottles
2448 F. A. A. Manier—Telegraphy
2449 H. N. Nissen—Printing
2450 W. H. Maitland—Coating iron
2451 A. M. Clark—Valves

DATED SEPTEMBER 18th, 1871.

2452 F. H. March—Bottles
2453 H. Halliwell—Driving bands
2454 W. H. Tooth—Cartridges
2455 W. Smith—Stove
2456 J. G. Jones—Sewing machines
2457 J. Kaye—Lamps
2458 D. Fryer and R. Steers—Roughing for shoes of horses
2459 E. H. Huch—Keeping off flies

DATED SEPTEMBER 19th, 1871.

2460 M. and D. Pedley—Looms
2461 T. H. Menke—Sewing machines
2462 W. Pawson—Taps
2463 R. R. Underwood and D. Thomson—Spindles
2464 T. H. Drew—Clipping horses
2465 J. H. Sanders—Wheeled carriages
2466 B. Brown—Boilers
2467 W. R. Lake—Torsion springs
2468 S. S. Lewis—Paper, &c.
2469 C. Pinn—Water-supply apparatus

DATED SEPTEMBER 20th, 1871.

2470 J. Owen—Filters
2471 J. Shanks—Bath fittings
2472 N. Miles—Bell gong
2473 W. C. Taylor—Safety valves
2474 J. S. Dronsfield—Grinding cards
2475 H. G. Sievier—Umbrellas
2476 L. Dietrichsen—Safety hoist
2477 E. Molyneux—Pianos, &c.
2478 A. Wilson and G. B. Wood—Making steel
2479 W. Martin—Lace machinery
2480 T. Radford—Creel frames

DATED SEPTEMBER 21st, 1871.

2481 F. Parry—Drying sewage
2482 A. Brodie—Belts
2483 J. Neilson—Enamelling
2484 C. H. Furlong—Treating casks
2485 W. R. Lake—Soles of boots
2486 C. H. Gardener—Holding parcels
2487 J. W. McCarter—Sawing machinery
2488 C. H. Gardner—Composing type
2489 A. W. Hosking—Advertising
2490 W. E. Gedge—Sponge
2491 W. E. Gedge—Dressing staves
2492 I. Aldebert—Carriages
2493 T. J. Smith—Waggons

DATED SEPTEMBER 22nd, 1871.

2494 E. T. Hughes—Lubricators
2495 J. Banks and W. Walker—Treatment of sewage
2496 T. Deffiis—Glass lights
2497 J. Williamson and W. Glazier—Dry closets
2498 C. A. Hardy, A. E. Stayner, and J. Harrison—Picks, &c.
2499 V. Count di Tergolina—Horses' bits
2500 J. C. Sellars—Charring peat
2501 A. V. Newton—Brushes
2502 W. E. Gedge—Cleaning grain
2503 W. E. Gedge—Shoe and gaiter
2504 B. Hunt—Quilting machines
2505 W. H. Kent—Plaiting
2506 R. and R. Bickertou—Reaping machines
2507 N. L. M. Smith—Water meter
2508 W. Lowman—Applying motive power

DATED SEPTEMBER 23rd, 1871.

2509 W. Tranter—Firearms
2510 W. E. Gedge—Lighting apparatus
2511 J. Verity—Chimney for gas burners
2512 J. B. Muschamp—Liquid meter
2513 A. M. Clark—Valve motion
2514 J. O. Greenwood, D. Mills, and M. Pearson—Weaving
2515 M. J. Haines—Improved packing
2516 F. Claudet—Treating solutions
2517 A. Parkes—Iron
2518 T. C. Eastwood—Combing wool
2519 J. Pinder—Securing windows
2520 T. A. Elliott—Reefing mainsails
2521 C. Muratori—Compound
2522 E. C. Green—Small arms
2523 W. Newell—Metallic handles

DATED SEPTEMBER 25th, 1871.

2524 W. Rollason and N. Brough—Spring metal box
2525 G. H. Andrews and W. Gibbs—Treatment of plants
2526 C. Wall—Portable holder
2527 C. A. Hardy and A. E. Stayner—Shafting picks
2528 J. Bailey—Joint
2529 A. B. Brown—Slide valves
2530 E. H. anu G. Hattou—Working rollers, &c.
2531 E. Baudot and E. Roettger—Obtaining motive power
2532 E. Dodgeon—Frames

DATED SEPTEMBER 26th, 1871.

2533 J. Shepherd—Separating water from steam
2534 C. R. Mathews—Gas pendants
2535 R. Girdwood—Crushing grain
2536 J. Simpson—Hydraulic presses
2537 A. Wallis and C. J. Steevens—Feed-water heaters
2538 J. Harrington and W. F. Richards—Imitation morocco
2539 W. A. Gibbs—Drying machinery
2540 J. White—Burning smoke

DATED SEPTEMBER 27th, 1871.

2541 A. Bresson—Asphalte
2542 J. Huggins—Tubes
2543 J. M. Kilner—Control of cables
2544 D. P. Blaine—Brake
2545 W. E. Gedge—New fabric
2546 A. Pécaud—Brake
2547 E. T. Hughes—Cooking utensils
2548 W. and J. Ireland—Steel ingots
2549 J. Apperly—Stamp receptacle
2550 S. J. MacCarthy—Fastenings for windows, &c.

DATED SEPTEMBER 28th, 1871.

2551 S. Schuman—Fulling, &c.
2552 F. Lacey—Ventilating rooms
2553 G. Davey—Artificial marble
2554 W. R. Lake—Artificial asphalte rock
2555 W. A. Jackson—Grinding saws
2556 J. F. Cooke—Pencils
2557 J. Young—Carbonic acid
2558 J. Young—Carbonate of soda
2559 H. P. Armstrong—Instrument, &c.
2560 J. Dendy and A. Taylor—Jacquard apparatus
2561 N. C. Underwood and W. Adshead—Felting hat bodies
2562 G. White—Pendulum levels
2593 R. Long—Refrigerator
2564 W. Mackay—Anchors
2565 S. Lees—Safety valve
2566 G. C. L. Lenox—Anchors

DATED SEPTEMBER 29th, 1871.

2567 C. de Chastelain—Treating sewage
2568 J. G. Tongue—Guns
2569 G. Ainsley—Velocipedes
2570 H. Watson—Strainer plates
2571 J. L. Norton—Drying wool
2572 H. Turner—Ceilings
2573 F. Coles—Freezing apparatus
2574 T. G. Greenstreet—Cleansing streets
2575 E. P. Baville—Tool holders
2576 J. Tinn—Boilers
2577 J. Taylor, A. Clegg, and J. Taylor—Looms
2578 M. Wilson—Stench traps
2579 A. V. Newton—Thrashing corn
2580 W. E. Gedge—Screening apparatus
2581 E. T. Hughes—Reeling machinery
2582 E. Edwards—Pressing metal

DATED SEPTEMBER 30th, 1871.

2583 G. Haseltine—Churns
2584 J. Pickering—Candles
2585 M. A. Wier—Signals
2586 J. Rogers and G. de Meirelles Soares—Asphaltic paving
2587 J. M. Plessner—Obtaining motive power
2588 W. Goreham—Cement
2589 C. Catlow—Looms
2590 H. Stevens—Cataloguing, &c.

DATED OCTOBER 2nd, 1871.

2591 H. Stapfer—Filtration of oil
2592 F. Westinghouse—Obtaining motive power
2593 T. Waller—Arrangements for the supply of fresh air
2594 L. Blaise—Urinometers
2595 G. D. Davis—Mooring buoys
2596 T. and F. H. Varley—Electric telegraphs
2597 N. D. Spartali—Propelling vessels
2598 A. V. Newton—Sad iron
2599 W. R. Lake—Inflammable gases

DATED OCTOBER 3rd, 1871.

2600 H. R. Harper—Lifting cranes
2601 A. E. C. Landry—Confectionery
2602 F. S. Stoney—Ferrule
2603 H. Jackson—Drying grain
2604 T. Jackson—Pianoforte action
2605 J. H. Kearns—Blotting pad
2606 W. T. Walker—Apparatus used in gasworks
2607 W. R. Lake—Governors
2608 C. L. H. Moesch—Bed chair
2609 T. Ball—Treatment of ammoniacal liquor
2610 A. Serre—Stopping runaway horses
2611 J. E. Liardet—Working ordnance
2612 J. H. Johnson—Puddling iron
2613 J. H. Johnsou—Water meters
2614 H. Kinsey—Steam winches
2615 J. H. Johnson—Ordnance
2616 A. M. Clark—Steam generators

DATED OCTOBER 4th, 1871.

2617 C. W. Granville—Paper pulp
2618 E. V. Neale—Stopping angular motion, &c.
2619 J. C. Evans—Treatment of horn
2620 D. Jones—Generating vapours
2621 G. Walker—Cloth for nail bags
2622 E. Davies and J. Leyland—Wrought iron nuts
2623 E. E. de Lobstein—Coating metals
2624 J. J. Stokes—Pencil, &c.
2625 F. Candy—Making roads
2626 W. I. Ellis—Forcing air
2627 J. L. Norton—Stair treads
2628 L. Pocock—Drying guano
2629 B. Davies and J. Eckersley—Furnaces
2630 L. H. Lumb—Baths
2631 A. M. Clark—Alimentary preparations
2632 A. M. Clark—Treadles

DATED OCTOBER 5th, 1871.

2633 N. Wilson—Sewing machines
2634 G. W. Pittman—Heckling hemp
2635 G. Demailly—Disaggregating plants
2636 J. Sidebottom—Furnaces
2637 E. P. Bernard—Tin boxes
2638 W. Nunn—Carriages
2639 R. D. Morgan and J. P. Van der Meulen—Railway chair
2640 A. Browne—Toy for children
2641 J. P. Furness—Fixing teeth to mowing machines
2642 H. Sprengell—Explosive compounds
2643 J. Gowans—Traction car
2644 J. Gowans—Tramways, &c.
2645 C. Tebbitt—Paper damper
2646 J. Ball—Reaping hooks
2647 G. L. Scott—Ventilating mines
2648 H. Walker—Button hole cutter
2649 W. H. Williams—Moustache protectors

DATED OCTOBER 6th, 1871.

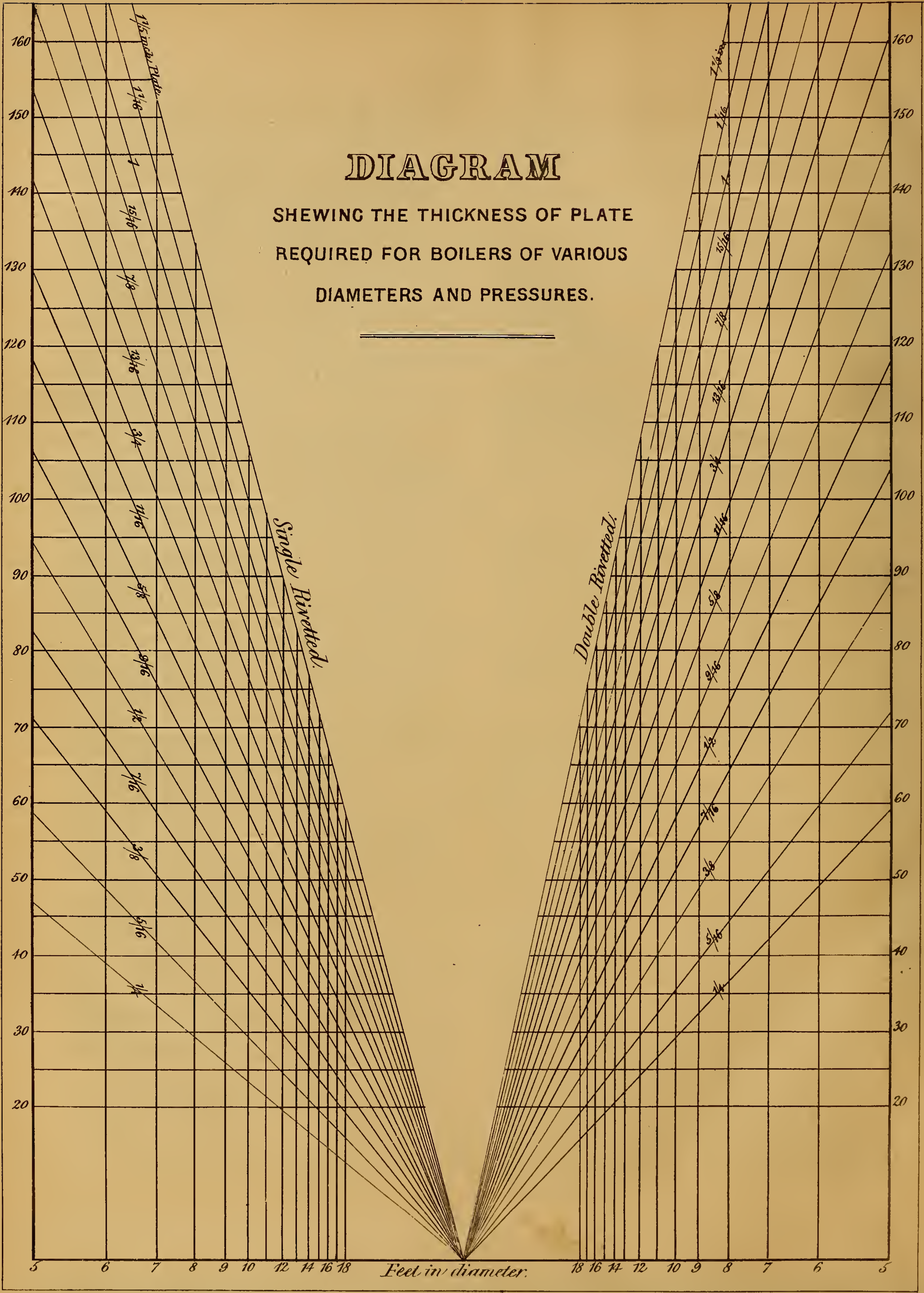
2650 T. Cole—Vent pegs
2651 W. R. Lake—Elevators
2652 B. Hunt—Steam boilers
2653 H. A. Vernon—Enabling heavy gun to be readily moved
2654 G. Stevenson—Manufacture of iron
2655 A. H. Still and D. Lane—Gas

DATED OCTOBER 7th, 1871.

2656 H. Jackson—Washing wool
2657 J. Darlington—Steam engines
2658 T. Robinson—Furnaces
2659 J. Burrow—Treating sewage
2660 H. Y. D. Scott—Treatment of refuse lime
2661 M. Tossill—Ventilation
2662 J. F. G. Kromschroeder—Generating inflammable gas

DATED OCTOBER 9th, 1871.

2663 R. Hall—Lids of tins, &c.
2664 J. T. Parlour—Raising sunken ships
2665 F. T. Aldridge—Hat bodies
2666 J. Stockley and M. Stainton—Steam engines
2667 H. Deacon—Sulphate of soda
2668 J. H. Johnson—Lanterns
2669 S. Cotton—Hackling hemp
2670 G. E. Smith—Gas burners
2671 W. R. Lake—Fastening for boots
2672 R. Goll—Cowls
2673 E. C. Clift—Vehicles
2674 T. Walker—Printing machines
2675 H. Hughes—Windows
2676 T. J. Smith—Treating filaments
2677 W. Yates—Lamps
2678 W. E. A. Hartmann—Burning fuel
2679 A. M. Clark—Self-acting fan



P. Soames, A.K.C. direx.

THE ARTIZAN.

No. 12.—Vol. V.—Fourth Series.—Vol. XXIX. From the Commencement.

1st DECEMBER, 1871.

DIAGRAM ILLUSTRATING THE SAFE PRESSURE FOR CYLINDRICAL STEAM BOILERS.

(Illustrated by Plate 380).

As the cylindrical form for steam generators has become almost universal for land purposes, and is steadily gaining ground with marine engiueers, the diagram shown in Plate 380 will, we trust, be of use to our readers. For high pressures it is obvious that a circle has great advantages over any other shape for the cross section of a boiler, inasmnch as the pressure is cqual in every direction. In the case of marine boilers, where, until lately, a very moderate pressnre was employed, it has been generally considered that the outline of the shell of the boiler should conform to the midship section of the vessel; bnt at the present time, when compound engines worked by high-pressure steam, are almost nniversally adopted, cylindrical boilers are generally employed.

The calculations necessary for determining the thickness of plates required for a boiler of a given diameter, and to be worked at a given pressure, are certainly not elaborate, nor is the converse of this proposition at all difficnlt, viz., the calculations necessary for determining the safe pressure at which a boiler of ascertained dimensions and thickness of plate can be worked. But it freqnently happens with manufactnrers of steam boilers that they are called upou to decide these questions off-hand, when a slight oversight in their calculations might be of very serions consequence. It is in order to enable them to see at a glance, withont the possibility of a mistakc, that the diagram (Plate 380), has een engraved.

The simple rnle for estimating the strength of a cylindrical boiler is too well known to onr readers to need any explanation. It is usually given in the following formula—

$$p = \frac{2\,s\,t}{d}$$

When p = pressure in lbs. per square inch at which the boiler is calculated to be worked, s the safe strain upon the iron in lbs. per sqnare inch section, t the thickness of the plate in inches, or fractions of an inch, d the diameter (in iuches) of the boiler. As, however, we are just now considering more particnlarly the safe strain to which a boiler may be worked, thc formula may be transposed thus—

$$s = \tfrac{1}{2}\frac{d\,p}{t}$$

According to the best anthorities, especially to Sir William Fairbairn, whose experiments upon this snbject have been most exhaustive, it appears that a tensile strength of 34,000lbs. on the square inch may be considered to bc the nltimate bursting strain of a boiler, the seams of which are single rivetted. As, however, a boiler is not usually designed to burst, but to work with perfect safety, a very much lower tensile strain than 34,000lbs. must be taken as the basis of our calculations. In order to be perfectly on the safe side it is usnal to take one-sixth of the bursting strain as a safe pressure at which to work a boiler. This will rednce s from 34,000lbs. to 5,666lbs., upon which datnm the left-hand diagram, Plate 380, is calcnlated.

Assuming, therefore, that 5,666lbs. per square inch is the safe teusile strength at which a boiler may be worked, the calculations for the strength of boilers becomes very simple. Thus, as Sir William Fairbairn remarks, "the divellent force tending to rupture the boiler-plates in longitndinal lines parallel to the axis of the boiler is in thc direct ratio of the diameter of the boiler," or, in other words, the shell of a cylindrical boiler of 3ft. in diameter, and ¼in. thick, is of the same strength as a boiler 6ft. in diameter composed of ½in. plates.

It is upon this principle that the diagram (Plate 380) has been designed. The figures at the bottom give the diameters of the boilers in feet, those on the vertical lines are the pressures in lbs. per sqnare inch at which the boilers may be safely worked; and the fignrcs on the diagonal lines represent the thickness of the plates. Thus, the diagoual line marked ½ shows that thc safe working pressure for a boiler of 5ft., or 60in. in diameter, is somewhat less than 95lbs., which, when calculated by the formula

$$s = \tfrac{1}{2}\frac{d\,p}{t}$$

is

$$5{,}666 = \tfrac{1}{2}\,\frac{60\,p}{\cdot 5} = 60\,p$$

$$\therefore\ p = \frac{5\cdot 666}{60} = 94\cdot 4\text{lbs. per square inch.}$$

By halving the distance between the outer perpendicular, representing the line of safety for a 5ft. boiler, and the centre from which the diagonal lines are strnck, and erecting another perpendicular from that point, it is found that the diagonal is cut at about 47lbs., or at one-half the pressnre referred to above. This is in accordance with the rule already mentioned, viz., that the strain on the boiler is in direct ratio to its diameter. The diagram is too simple to require any further explanation, as it is only necessary to see where a diagonal line representing a certain thickness cnts a vertical line representing the required diameter, to see at once by referring to the horizontal line next below that point the pressnre at which it is safe to work. If the diameter of the boiler bc determined, and also the pressure at which it is to work, the diagonal next above the intersection of the vertical and horizontal lines (representing the diameter and pressnre respectively) will at once give the proper thickness. For instance, if it be required to construct a boiler of 7ft. in diameter, to be worked with 75lbs. steam, a reference to the diagram will show that a $\frac{9}{16}$in. plate will be neccssary, the diagonal representing that thickness cutting the two othcr lines just above their intersection.

The right-hand diagram is constructed upou precisely thc same principle, but the safe strain to which a double-rivetted plates may be subjected being considerably greater than that which is only single rivetted, a corresponding modification in the diagram has been necessary.

Sir William Fairbairn's experiments show that the strength of double-rivetted joints is to that of single rivetted as 70 to 56. The reason of this will be easily understood by taking a single example. Supposing for this case we take two plates $\frac{11}{16}$in. in thickness. For single rivetting the anthority just quoted would specify 1in. rivets at 2¾in. pitch, that is, the centre of the rivet holes to be 2¾in. apart. The net area of plate between the rivet-holes would consequently be $(2\tfrac{3}{4}-1) \times \tfrac{11}{16} = 1\cdot 2003$ square inches.

For donble rivetting the same authority would specify ⅝in. rivets at 3in. pitch. In this case the net area of the plate would be—

$$(3 - \tfrac{5}{8}) \times \tfrac{11}{16} = 1\cdot 4609 \text{ square inches.}$$

Applying these resnlts to the strengths credited to double and single rivetted plates, we find the following proportion—

As 1·2003 : 1·4609 :: 56 : 68·148.

It will be seen that in this case, instead of 70 we only get 68·148, but when it is considered that a mnch larger surface of plate is in contaet when donble rivetted, it can be re adily nnderstood that the extra cohesion resulting therefrom would make np the difference.

The reason for using 1in. rivets in the first casc and ⅞in. in the second, is in order to get the area of rivet and area of plate as nearly eqnal as possible without using very fractional pitches and diameters. By butting the plates and rivetting through inside and ontside bnt-straps the 70 per cent. may be considerably increased.

ON THE APPLICATION OF VARIABLE CUT-OFF VALVES TO WINDING ENGINES.

In the present article we pnrpose describing and giving some statistics of the working of a new variable cut-off arrangement, which has now been in use abont two years, in connection with the winding engines of the Mines de Blanry, being invented and applied by M. H. Andemar, the engineer to those workings; but previonsly to entering npon the details we must briefly revert to the difficulties militating against the applieation of the ordinary cut-off to engines of the class referred to.

It is in the highest degree necessary that winding engines shonld in all cases be simple and easily managed, and any appliance causing the engine driven additional work is necessarily a great objection.

Again, the position of winding engincs in connection with coal mines renders the consideration of consnmption of fnel a minor question, as refnse can be burnt which would otherwise be destroyed, causing economy of fuel a matter of little or no importance.

There is, however, one other point to observe, which is, that economy in working an engine means something more than economy of fuel, for it only secures that by economising steam; and economising steam requires fewer boilers, and thus the cost of plant is kept to a minimum. By the application of this contrivance to the engines of the above mines a large amount of capital was saved which had been voted to be expended on several new boilers, to meet the increasing reqnirements of the workings.

It may also be observed that in many localities, pits are being worked which yield only a class of mineral that would not have been thought worth the tronble of getting some years since; and these matters all lead to the exercise of increased economy.

The following is a snmmary of the conditions required to be satisfied in order to secure satisfactory resnlts in applying the new arrangement—

1st. To work the engine without cut-off throughont by the cam.

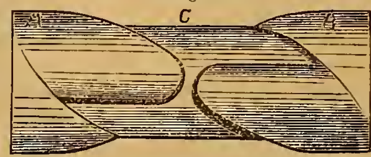
2nd. To have a cut-off variable at will.

3rd. Not to angment the number of levers necessary to work the engine, or to inerease perceptibly the force necessary to move the previonsly existing levers.

Fig. 1 shows a side elevation of tho double cam drawn to a scale of one-eighth fnll size. The two extremities A and B are cylindrical, and just beneath them the cambers commence, terminating in a cylindrical part at the centre C.

This cam is cansed to rotate on a shaft, which is so connected with the main shaft of the engino so as to impart to it the necessary revolntion; and it also has an adjustment connected with the ordinary reversing lever by which it is moved longitndinally on the shaft on which it is carried, thus bringing any portion of the cam to act npon the lever working the cut-off as may be required.

Fig.



It will be observed that one end of the cam corresponds with the forward end of the link motion, and the other with the backward end, as shown in Fig. 2.

A (Fig. 2) shows the valve chamber, containing an ordinary double-beat valve, which is normally kept closed by the weight, B, placed upon the valve spindle. C is the donble cam actuating the cnt-off valve through the roller, G, at the lower end of the bent lever, G P Q.

The cam is carried on and revolves with the shaft, F, but admits of rising and falling, which is caused by the disc, D, on the shaft, E, raised or depressed by the reversing lever, H, hinged on the fnlcrum, I, and having forged on it the tee piece, K L, the rod, K, working the cnt-off,

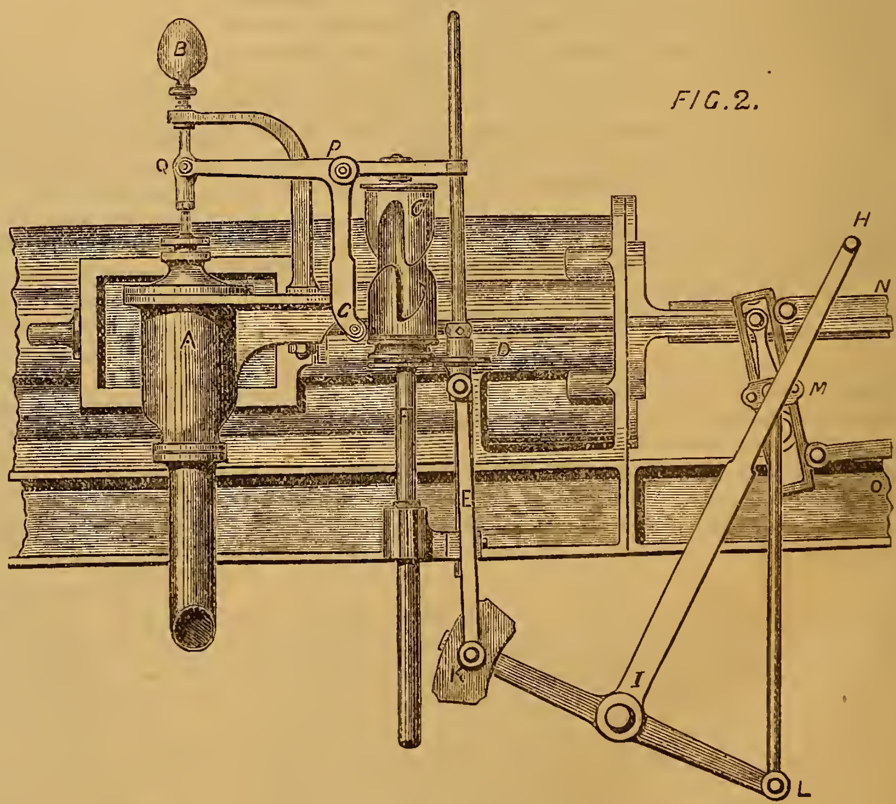


FIG. 2.

and the end, L, actuating the link, M, worked by the connecting rods, N and O, which are attached to the backward and forward eccentrics.

The economy of fnel and steam attained by this arrangement, after two years' trial, has been fonnd, with ordinary pressures, to amount to

37 per cent., and with high pressure (up to 75lbs. per square inch), to reach 42 per cent. The following tables show the registered results :—

TABLE I.

Proportion of stroke before cut-off.	Proportion of stroke after cut-off.	Work done before cut-off.	Work done after cut-off.
Full steam	0	100	0·00
„ $\frac{3}{4}$ ...	$\frac{1}{4}$	100	28·70
„ $\frac{2}{3}$ ...	$\frac{1}{3}$	100	40·50
„ $\frac{1}{2}$ ...	$\frac{1}{2}$	100	69·30
„ $\frac{1}{3}$ ...	$\frac{2}{3}$	100	109·80

TABLE II.

Initial pressure in atmospheres.	Work done per kilo. of vapour.	Limit of cut-off.
5	16·018	$\frac{2}{3}$
4	14·726	$\frac{3}{5}$
3	12·773	$\frac{1}{2}$
2	9·266	$\frac{1}{4}$

STRENGTH OF SPUR WHEELS.

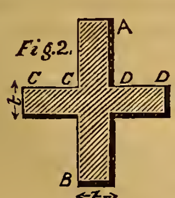
By FRANCIS CAMPIN, C.E.

(*Concluded from page* 223.)

If the rim of the wheel were perfectly hard and inelastic it stands to reason that the strain would be equal on all the arms, but this not being the case the strains vary according to the compression or extension of the rim.

For all practical purposes we may assume that the maximum strain that will come on one arm is one-half of the total transmitted strain. Let the force transmitted be 10,000lbs. on the teeth of the wheel, then on any arm there may come a force of 5,000lbs., tending to break it like cantilever:

Fig. 2.



In Fig. 2 is shown a section of an arm, but it might, of course, be of square, circular, or other section.

The direction of pressure is from A to B, or from B to A, and the force according to discretion is regarded as being withstood by the whole section, or by the parts A B only; in the latter case the webs C C, D D, only act as lateral stiffeners to the wheel.

We will act upon the latter assumption, then A B is the depth of the cantilever, and its length is equal to the distance from the outside of the boss to the pitch-line of the teeth.

Let the length of the arm be 20 inches. If W = the force acting at end of the arm, t the thickness, d the depth, and l the length, then for the breaking weight we find—

$$W = \frac{8000\ t\ d^2}{l}$$

all the dimensions being in inches, and the force in tons.

And if the safe working load is taken at one-sixth of the breaking weight the formula becomes—

$$W = \frac{1333\ t\ d^2}{l}$$

from which the formulæ for depth and thickness are obtained.

$$t = \frac{W.l}{1333.d^2}$$

$$d = \sqrt{\frac{W.l}{1333.t}} = 0·027\sqrt{\frac{W.l}{t}}$$

In the foregoing case assume the depth of cantilever, or width of arm at the boss, as 8 inches, then, the safe load being 5,000lbs, and the length 20 inches, we have for the thickness—

$$t = \frac{W.l}{1333.d^2} = \frac{5000 \times 20}{1333 \times 8 \times 8}$$

$$= \frac{100000}{85312} = 1·17 \text{ inches}$$

This applies to wheels having four arms.

If the wheel has six arms we may assume the maximum strain on any arm at one-third the total load, and the thickness would be—

$$t = \frac{W.l}{1333.d^2} = \frac{3333 \times 20}{1333 \times 8 \times 8}$$

$$= \frac{66666}{85312} = 0·78 \text{ inches}$$

Suppose, however, in the first case (four arms) it is decided to make the arms 3 inches thick, the requisite depth will be—

$$d = 0·027\sqrt{\frac{W\ l}{t}} = 0·027\sqrt{\frac{5000 \times 20}{3}}$$

$$= 0·027\sqrt{\frac{100000}{3}} = 0·027\sqrt{33333}$$

$$= 0·027 \times 183 = 4·94 = \text{(say) } 5 \text{ inches.}$$

This then will be the requisite width of the boss, whence it may be diminished by any suitable taper down to the rim of the wheel, for the strain upon the arm is at its maximum where the arm joins the boss, and then diminishes to *nil* at the pitch circle of the teeth, and the strain on any part of the arm is in direct proportion to the distance of such part from the pitch circle. Thus at the centre of the arm the strain is half as great as at the boss, and so on.

For a different number of arms it may be generally assumed that the strain at a maximum on any arm is equal to the total force divided by half the number of arms.

Let P = pressure on teeth.
n = number of arms.
W = maximum load on any arm.

$$W = \frac{2\ P}{n}$$

Let P = 5600lbs., n = 5 arms,

$$W = \frac{2\ P}{n} = \frac{2 \times 5600}{5} = 2240\text{lbs.}$$

The parts of the arm shown at C C, D D, in Fig. 2, do not add much to the strength of the arm to resist the stress of which we are now treating, as they lie too near to the centre or neutral axis of the cantilever.

Thus, if these portions be 2 inches square each, they will together be equal to a solid cantilever 4 inches wide and 2 inches deep, and the portion A B has been shown to be 5 inches deep and 3 inches wide.

The transverse strength of solid beams (rectangular in form) varies as the breadth and as the square of the depth.

Let b d represent the breadth and depth of one beam.

B D „ „

R „ ratio of strengths.

$$R = \frac{b \cdot d^2}{B.D^2}$$

in the present instance,

$$R = \frac{b \cdot d^2}{B.D^2} = \frac{4 \times 2 \times 2}{3 \times 5 \times 5}$$

$$= \frac{16}{75} = 0.21, \text{ or nearly } \tfrac{1}{5}$$

There is another matter to be considered in connection with wheels, which is the effect of certain strains common to all rotating bodies, and caused by the centrifugal force which the rotation calls into action. This force acts primarily in a radial direction, but it may be resolved into tangential force; hence the intensity of it in its direct action can be ascertained.

First, we will consider the rim of the wheel—

Let v = velocity of periphery in feet per second.

n = number of revolutions per minute.

d = diameter in feet.

w = weight per foot of rims in lbs.

a = sectional area of rim in square inches.

c = centrifugal force in lbs.

Then for one foot of the rim we find—

$$c = \frac{w \times v^2}{16.1 \times d}$$

from the ordinary formula for centrifugal force.

We will treat this as a simple radial force tending to burst the ring, and call S the tensile strain on any section of the rim—

$$S = \frac{c\,d}{2}$$

but from the foregoing equation,

$$d = \frac{w.v^2}{16.1.c}$$

Wherefore

$$S = \frac{c}{2} \times \frac{w\,v^2}{16.1.c}$$

$$= \frac{w\,v^2}{32.2}$$

Then allowing 1800lbs. per square inch as the tensile working strength of cast iron the sectional area of the rim should be—

$$a = \frac{w.v^2}{32.2} \times \frac{1}{1800}$$

$$= \frac{w\,v^2}{57.960}$$

But from the specific weight of cast iron it is found that—

$$a = \frac{w}{3.2}$$

Also,

$$n = \frac{60 \cdot v}{3.1416.\,d}$$

$$= \frac{19 \cdot v}{d}$$

And therefore,

$$v = \frac{n \times d}{19}$$

Whence by replacing in the various equations we deduce the limiting velocity for a cast iron wheel working safely

$$n = \frac{2546}{d}$$

NOTE.—For a wrought iron rim it would be—

$$n = \frac{4427}{d}$$

In the next place the strength of the arms to resist centrifugal force must be considered, as if the rim be flawed it will be held by the arms alone. The portion of the periphery of which the centrifugal force should be sustained by one arm is that part lying between two arms.

Let a = sectional area of rim in square inches.

d = diameter of wheel in feet.

v = velocity in feet per second of rim.

A = area in square inches of one arm.

N = number of arms in the wheel.

Then because a one inch square bar of cast iron one foot long weighs 3.2lbs., the weight of the rim is

$$W = a \times 3.2 \times 3.1416\,d = a.\,10.\,d.$$

hence the centrifugal force on all the arms may be

$$c = \frac{W\,v^2}{16.1 \times d} = \frac{10.a.d.v^2}{16.1 \times d}$$

$$= \frac{a\,v^2}{1.6}$$

But,

$$v = \frac{n \times d}{19}$$

hence,

$$c = \frac{a\,(n.d)^2}{577.6}$$

The safe resistance of all the arms will be—

$$= A \times N \times 1800$$

hence,

$$1800.A.N. = \frac{a\,(n.d)^2}{577.6}$$

$$A = \frac{a\,(n.d)^2}{1{,}039{,}680.\,N}$$

From these formula we can for example find the highest safe velocity at which the foregoing wheel could be run. The length of one arm being 20 inches its diameter would be 4 feet—

$$n = \frac{2546}{d} = \frac{2546}{4} = 636.5 \text{ revols. per minute.}$$

It is but seldom that spur wheels are run anywhere near their limiting velocities, but it is nevertheless necessary to consider the possibility of such cases arising.

As we have already observed, much depends upon the workmanship put into wheels, and before calculating for heavy mill work it is always advisable to inform ourselves of the average quality of work we may obtain.

Before concluding the present paper we will enter briefly upon the method of determining the maximum pressure on the tooth of a spur wheel.

It is very improper in all cases to calculate from horse-power, for it may happen that at a certain position of the pistons the strain is much above the average.

The moment of strain upon a revolving shaft is found by multiplying the strain by its distance from the centre of revolution.

Let the piston of an engine have a diameter of 20 inches, then its area will be,

$$= 314 \text{ square inches,}$$

A maximum pressure of 40lbs. per square inch would give as gross pressure

$$314 \times 40 = 12{,}560\text{lbs.}$$

Let the crank be 2ft. long, then as this force can never act at a greater

distance from the centre of rotation than the length of the crank the maximum moment will be

$$12,560 \times 2 = 25,120 \text{ foot lbs.}$$

If there be keyed on the engine-shaft a wheel of 4ft. radius the greatest pressure given off by one of its teeth will be found by dividing the moment of force by the radius,

$$\frac{25120}{4} = 6280\text{lbs.}$$

will be the maximum force on one tooth.

The pressure on one tooth of a driven wheel is the same as on one tooth of the driver.

If there are two spur wheels on one shaft one (w) receiving motion and so communicating it to the shaft, and the other (W) giving it off to a fourth wheel, if p be the pressure of the teeth of w, and r and R the respective radii of the wheels, then the pressure P on the teeth of W will be thus found

$$P \times R = p \times r$$

because the power being transmitted through the shaft unaltered, the moments of stress must be equal at both points of reception and distribution, hence

$$P = \frac{p.r}{R} \text{ or } R = \frac{p.r}{P}.$$

APPRENTICES TO THE SEA SERVICE.

We have been requested to publish by the Right Hon. Chichester Fortesque the following caution to intending sailors, which we willingly do, as that class of persons are undoubtedly swindled by impostors:—

The Board of Trade have from time to time proceeded against persons in London and elsewhere who have been in the habit, although unauthorised by law to do so, of advertising employment for boys and officers for the sea service. They regret to find that, in spite of the warning conveyed by these proceedings, and notwithstanding the penalties to which they render themselves liable, owners and masters of ships, as well as parents and guardians of boys, are often still so unguarded and ill-informed as to employ these unauthorised and unqualified advertising agents instead of the officers duly appointed by law to enrol apprentices, and to facilitate their employment in British ships.

The Board of Trade therefore think it right to point out to the friends and relatives of boys and persons seeking employment at sea, as well as to the owners and agents of ships, that by the 141st section of "The Merchant Shipping Act, 1854," all superintendents of mercantile marine offices are required to give to "persons desirous of apprenticing boys to the sea service, and to the masters and owners of ships requiring apprentices, such assistance as is in their power for facilitating the making of such apprenticeships." The Board of Trade regard this as one of the most important duties thrown by the legislature on superintendents; and, in order to carry the intention of the statute into effect, each superintendent is directed to keep two registers—one containing a clear and methodical record of the names, ages, addresses and other particulars received by them with respect to boys seeking employment at sea, the other containing the names of owners who are desirous of obtaining boys for their ships.

It is important that owners and agents should be aware of this arrangement, so that when they require the services of boys or youths they may apply directly to a superintendent of a mercantile marine office instead of a slop-seller or other person not authorised by law to procure employment for seamen.

To widows (who appear to be frequently deceived by persons styling themselves shipping agents or agents for supplying seamen, but who in reality gain their livelihood by plundering the unwary or ill-informed), and to all other persons having the charge of boys, and wishing to apprentice them to the sea service, the Board of Trade would point out that the authorised superintendents at the Government mercantile marine offices (there is one at every port), who will register the boys' names as applying for employment, have more facilities for finding employment at sea for a boy than any other person, and are besides the only persons who can legally receive any remuneration for doing so. The fee for each apprenticeship effected with the superintendent's assistance is limited to five shillings. Those of the public who continue, in the face of the caution issued by the Board of Trade, to employ and pay persons by law unauthorised to procure employment on board ship for boys, are not only wasting their money, and incurring a penalty in each case of £20, but are absolutely encouraging the breaking of the law, as well as aiding the crimp and slop-seller in setting aside those officers whose duty, under the law, is to enrol apprentices.

The Merchant Shipping Act, section 147, provides that:—1. If any unauthorised * person engages or supplies any mate, seaman, midshipman, or apprentice to be entered on board any ship in the United Kingdom, he will be liable to be prosecuted, and, if convicted, to a penalty of £20 for each offence; 2. If any person employs any unauthorised person he will be liable to be prosecuted, and, if convicted, to a penalty of £20 for each offence; 3. If any person knowingly receives or accepts to be entered on board any ship any mate, seaman, midshipman, or apprentice illegally engaged or supplied, he will be liable to a prosecution, and, if convicted, to a penalty of £20 for each offence.

And by the 148th section:—Any person, other than the superintendent of a Government mercantile marine office, who demands or receives, directly or indirectly, any remuneration whatever from any mate, seaman, midshipman, or apprentice, for obtaining them employment, will be liable to a prosecution, and, if convicted, to a penalty of £5 for each offence.

Any parent, guardian, officer, seaman, or apprentice, who has paid to any agent, slop-seller, crimp, or other unauthorised person, any sum for obtaining employment on any British ship in the United Kingdom, should at once communicate full particulars in writing (giving the names of the parties and of witnesses), to the Registrar-General of Seamen, 6, Adelaide-place, London-bridge, E.C., from whom may be obtained, free of charge, a printed list of persons authorised to engage or supply mates, midshipmen, apprentices, boys, and seamen for the merchant service, together with a list of the names of some unauthorised persons who have been convicted, but who still advertise in their own, or in other names.

The Board of Trade trust that ship owners, ship masters, and officers, parents, and guardians of boys, and superintendents of mercantile marine offices, will co-operate with them in opposing to the utmost and in bringing to justice any person who may hereafter unlawfully receive money for obtaining employment for seamen and apprentices.

Thomas Gray.

* The only persons authorised to engage or supply mates, seamen, midshipmen, and apprentices are the following:—The owner, the master, or the mate of the ship, or some person who is the *bona fide* servant and in the constant employ of the owner; the superintendent of a Government mercantile marine office, or an agent licensed by the Board of Trade.

ON THE COLOURS OF METALS.

By Professor C. A. Seely.

Of all the metals, two only, gold and copper, are distinctly coloured. When nicely polished the surfaces of all metals become nearly perfect mirrors, reflecting almost all the light, whatever be its tint, which falls upon them, and the chemically clean matte surfaces of all metals except gold and copper appear white to the eye. Yet the white light from such surfaces is invariably contaminated with a small amount of coloured light, and this coloured light is without doubt the result of a normal and ordinary decomposition of the incident white light. If the greater part of the incident white light were in the same way decomposed, the metals, instead of appearing to us white, would shine with splendid colours. The colours of natural objects are always mixed with white light, that is, the white light falling on the surfaces of natural objects is never completely decomposed, and in this regard the case of the metal shows a difference in degree and not in kind. To the eye of the scientist, then, all the metals may be coloured; the colours are ordinarily invisible simply because they are diluted or overpowered by the white light with which they are mingled. With the explanation thus given I assume in this paper that all metals are coloured. The most satisfactory method of rendering the colours of metals apparent heretofore proposed consists in repeatedly reflecting a beam of white light from the metallic surface under examination. A convenient arrangement is two parallel plates of the metal, between which the light is reflected from one to the other at a small angle of incidence. At each incidence the white light is partially decomposed, and if the number of incidences be sufficiently multiplied, all the white light will have disappeared, and only the pure coloured rays be visible. In this way the colours of most of the metals have been exactly determined. The actual experiment, however, is not a very brilliant one, inasmuch as the larger part of the light with which it begins is lost by gradual diffusion; especially the coloured light is so lost, probably for the reason that the decomposition of the white light takes place within the reflecting surface. Another method of developing the true colours of metals has recently occurred to me, and it is the main purpose of this paper to describe it. I present first a few theoretical considerations. When white light is decomposed by a coloured body, the reflected coloured ray is complementary to that part of the

white light which is transmitted or absorbed; if a coloured body be seen both by reflected and transmitted light, the colours so seen should be complementary, or an approach to being so. These statements seem to have many exceptions, as, for example, the coloured transparent salts of metals show the same colour by reflected as by transmitted light. But I am persuaded that a careful discussion of the case would show that such exceptions are not well taken, and that this apparent discrepancy with the statements may be consistently explained away; thus it may be shown that the supposed reflected light of the exceptions is really a part of the transmitted light which has been returned by internal reflection; such mixture of the transmitted with a reflected light implies a considerable degree of transparency of the substance under test. The lustre and whiteness of metals have a close relation to their opacity and density; perhaps the relation is that of effect and cause. If the opacity and density of metals be progressively decreased, the optical metallic character will in the same ratio be diminished; the true colour by reflected light would become brighter and freer from white light till it come to be contaminated with more and more of the returned transmitted light. Such changes are beautifully exemplified by the gradual additions of a solvent to fuchsine or other aniline colours in crystals. Aniline colours, Prussian blue, indigo, carmine, and all other dye-stuffs which have very great tinctorial powers, have the metallic lustre, and their colour by transmitted light is nearly complementary to that by reflected light. In their relation to light I suggest that metals are closely analogous to those dye-stuffs which show a bronzed surface by reflected light. Metals are more perfectly bronzed because their opacity and density are greater, or, in other words, their tinctorial powers are greater. It will be seen that the above theory requires for its demonstration a transparent diluent or solvent of metals, which shall have no chemical action on them. Such a solvent, for a few of the metals, is anhydrous liquid ammonia. If this menstruum be gradually added to the silver-white alkali metals, the whiteness disappears, is replaced by copper-redness, which at last gives place to the blue of transmitted light. The changes of tint in this case from copper-redness to the transparent blue may be exactly repeated by treating pure aniline blue with alcohol. The alkali metals are then copper-red in reflected light, and by transmitted light blue. In this connection, the fact that the salts of copper are blue is, perhaps, of some significance. The solution of metals without definite chemical action is almost a new idea in chemistry. Faraday made the first approach to it by showing that the colour of ruby glass is due to metallic gold; and it received a final and definite shape in a demonstration of the solvent properties of anhydrous liquid ammonia, which I made at the late Troy meeting of the American Association for the Advancement of Science. The tinctorial power of metals appears to be vastly greater than that of any known dye-stuff, and the colours they should yield are very brilliant. There is reason, then, to hope that these facts about metals may some day receive some useful application.

THE INDUSTRIAL CLASSES ABROAD.

The following are a few selected reports from the consuls of the several countries respecting the artisan abroad, which may perhaps be of use to some of our readers:—

Egypt.

The report furnished by the Consular Service at Cairo and Alexandria places us, for the first time, in possession of information respecting the condition of the industrial classes in Egypt. Reliable statistics are wanting, it seems, of the number of persons thus engaged; and the Consul-General, Mr. Stanton, is indebted to the assistance of his Excellency the Minister of the Interior, for the best approximate that can be obtained. Manufacturing and other industries, except in a rude state, are little developed amongst the native inhabitants of Egypt, which may be said to be essentially an agricultural country, and the citizen and industrial classes bear but a small proportion to the tillers of the soil and to the rest of the population. The total number of citizens amounts only to about 55,000, or to little more than one per cent. of the population, which is estimated to be about 5,000,000. The system of "osnafs", or guilds, has for centuries been established in Egypt, in every branch of native industry, and is probably maintained for the facilities it affords for the collection of the capitation and other personal taxes, as well as for the guarantee it is made to offer for the due execution of works ordered by the government.

Every esnaf is presided over by a sheikh, appointed by government nominally upon the recommendation of the higher members of the guild; he is actually the ruler of the guild; he admits members, directs the manner in which contracts shall be carried out, fixes wages, collects taxes from his guild, and is responsible to the government in all matters connected therewith. The industrial population of Egypt, with the exception of weavers, dyers, and basket-makers, appear to be confined to Cairo, Alexandria, and a few other of the large centres. The greatest number are, the weavers 10,001; carpenters and sawyers, 6,473; dyers, 5,109; masons, 4,113; goldsmiths and jewellers, 2,630; blacksmiths, 2,605; embroiderers, 1,871. With regard to the quality of work executed, as a rule, it is said to be unsatisfactory, though exceptions exist in some departments, especially in embroidery, specimens of which are occasionally produced in Egypt of good workmanship, though inferior to European productions. Considerable numbers of Europeans are engaged in the building and other trades, and as mechanics in the service of the government and private persons. Greeks, Italians, and Maltese are the most numerous, but of all people of European origin, the Greeks are the most pliable and successful; but few English citizens have set up in business on their own account, possibly from their habits not assimilating so readily with local circumstances as those from the south of Europe.

From Mr. Consul Stanley we learn the more detailed particulars respecting wages, clothing, diet, &c. English mechanics and artisans it seems are employed, with few exceptions, exclusively as engineers to steam-ships, drivers on railways, or in charge of machinery of all descriptions, and as plate-layers and fitters. They get high wages; engineers from £20 to £30 a month; drivers from £18 to £25, and plate, layers from £17 to £20 per month; and, with exception of the first, lodgings are provided. Egyptian boys and girls under 15, employed in the cotton factories, can be obtained in any number in the interior for 5d. per day, working from four in the morning till sunset. Egyptian men receive 1s. per day. Besides the cotton factories, the Viceroy has in Upper Egypt, many sugar manufactories, which give employ to a large number of Egyptians, and having each one or more European engineers. Foremen carpenters and blacksmiths, generally Maltese, are paid from 6s. to 8s. per day; ordinary carpenters 5s. to 6s. Greeks, who are inferior workmen, receive 3s. to 5s., but Corfiotes, get the highest wages viz., 6s. Egyptian workmen about 2s. per day; but they are rarely employed in European workshops, their work being of inferior quality. As to provisions, beef and mutton are about the same price per pound as in England. The beef is good, but the Syrian mutton imported and generally used in Alexandria, is very inferior. English mutton is killed in small quantities weekly, at 1s. per pound. Bread is one-third dearer also. Potatoes, cauliflowers, cabbages, peas, beans, and vegetables usually consumed in England, are dearer, but tomatoes, "bamias," the egg-plant, vegetable marrow, and yams, are good and cheap. Apples and pears, cost nearly twice as much as in England; the smaller fruit, such as cherries, currants, and strawberries, are rare and expensive; but there is an abundance of excellent and wholesome bananas, delicious figs, besides apricots, melons, grapes, and oranges. These are much cheaper than in England, but cows' milk costs twice as much. Buffalo's and goat's milk, much used, is good, and cheaper than cow's milk. French, Greek, and Italian wines can be got good and cheap, and are more suitable to the health than beer or strong wines. There is an abundance of bad, harmful spirits. English stores can generally be bought at 35 per cent. dearer than in England, and when imported direct by the user, about 20 per cent. The wear and tear of clothes, owing to the sun and dust, is greater than in England, and articles of clothing are dear. Rent is high; a mechanic would pay £36 a year for a suitable house, that in England would be got for £12 a year.

As a summary to Mr. Consul Stanley's remarks, it may be concluded that skilled labour costs twice as much as in England, rent nearly three times as much, necessary provisions a very little higher, so that a steady mechanic could certainly save more than he could in England, and in the large towns would live as well, and, indeed, would have many luxuries, cheap wholesome fruit for instance, to which he was unaccustomed. In the interior he would not live so well, but much cheaper. This saving is, however, dependant on him and his family having good health. Most of the ladies of the higher European classes go to Europe during the hot months, and the men every other year; those who have time and money to dispose of, every year. This would entail too much expense on the working classes, and the greater risk of illness, with its attendant loss of employ, must be taken into consideration by any workman deciding to settle in Egypt. Should he arrive under contract, a clause should be inserted, defining the wages he would get when ill, and stipulating that he be sent home at his employer's expense if absolutely incapable of work through illness. This might in all cases be made certain, by a sufficient sum being deposited in the consulate. It would especially guard against difficulty, were his employer an Egyptian, but with the government, or a European, it would be unnecessary.

Russia.

The condition of the industrial classes can only be imperfectly ascertained from the reports of the consular officials, at the various

districts scattered throughout the Russian Empire; these reports present certain features of interest, although there is but little deserving of imitation.

The Consul-General, Mr. Abbott, observes that the country of New Russia and Bessarabia, forming the government of which Odessa is the principal city, is not likely now to attract to it emigration from other parts of Europe. Though many colonies of Germans were founded in this part of the country at the end of the last and early in the present century, and those communities have, through the favour of the government, become very flourishing, this system has not been followed up, though it could not be otherwise than advantageous. The country which goes under the appellation of New Russia is, generally speaking, an open, bleak region, exposed in winter to intense cold. The same may be said of Bessarabia, though, towards the north, it is wooded, and rendered fertile by frequent rains; but throughout these countries the communication, excepting by the solitary lines of railway, is difficult, made roads unknown, and communication rendered almost impracticable after each fall of rain. Though possessing few attractions for the general emigrant, a good many English and Scotch have met with employment in it, either as engineers, mechanics, paviours, or stone-cutters, and many governesses and nurses from England are found in the country. The Russian artisans themselves are fast acquiring greater skill in all departments of their trade, for the Russian is of an imitative if not of an inventive turn of mind, and as he improves in skill he will naturally improve in the care and quality of the work he executes. The contract system prevails, so that parties dispose of their services in gangs, by the year or season, for any work that can be obtained. If a house is to be built, the architect has only to warn one of these contractors that so many masons or carpenters are required, and they are immediately supplied. The system has these advantages for the working man; he is provided for so much of the year, without having to seek more frequently for labour, and he has a certain sum to depend upon instead of an uncertain prospect of wages. With respect to the purchase-power of money, as compared with England, Mr. Abbott reckons it about two to three for the upper classes, whilst for the lower orders, whose diet is of the simplest and least expensive kind, living must be infinitely cheaper than in England. With respect to diet, the conditions essential for the preservation of health do not differ from those required generally in other parts of Europe. Provisions of most kinds are abundant and good. There would be great difficulty, generally speaking, for working men from abroad with respect to house accommodation as good as they have been accustomed to in England, and the distance from their work would often be unendurable; and if all the inconveniences are taken into account by an intending emigrant, very few, if any, would quit the shores of England to reside in Russia.

At Kertch, Mr. Consul Barrow informs us a house that would cost 200 roubles a-year rent, or £25, may be procured in England for as many shillings, say £10, and of a much better sort. The same with regard to clothing; a coat that costs 30s. in London is sold in Kertch for 30 or 35 roubles, each rouble on an average being worth 2s. 6d. Woollen shirts are from 10 to 15 roubles. As to provisions, meat, bread, and poultry alone are cheap, though the first item is much higher now than it was four years ago. Bread about 1d. a pound; sugar, 6d.; fresh butter, 1s. to 1s. 3d.; eggs, from 8d. to 1s. per dozen; fowls, from 1s. 6d. to 2s. the pair; salt butter, from Siberia, 7d. to 8d. per lb.; tea, of an inferior quality, 6s. per lb.; better quality at 8s.—the Russian lb. being less than the English by nearly one-tenth. Every item purchased in the shops may be reckoned in roubles for shillings, so that in reality wages of £20 a-month are scarcely worth more in purchase money than £8 to £10 at home. Fish is very cheap, and at times very abundant. The most wholesome beverage is the red Crimean wine, made from Bordeaux vines transplanted, diluted with water. The most injurious of drinks is the Russian "watkey," invariably detestable to the inhabituated, but upon the second or third trial it possesses an extraordinary fascination; and, after a few months, men who drink it, from being hale and hearty, are known to become grey-headed, stupefied, and rapidly approach the last stage of *delirium tremens*. In the hospitals, there is a scarcity of nourishment bordering on starvation, and an utter want of feeling or sympathy for the sick among the attendants.

Mr. Vice-Consul Stevens, writing from the district of Nicolaieff, gives some instructive advice upon the subject of this inquiry. He observes how recent Russian resolve requires all Russian enterprise to employ no foreigners or foreign material if they can be avoided; and it is notorious that foreigners are only sought where and when the Empire fails in supply, and then the most binding contracts are useless once the foreigners' art is learnt tolerably well by the natives, who are quick at imitation. The smallest pretext is made an excuse for dismissing the foreigner; he is arbitrarily dismissed, and his only hope for even moderate redress lies in the influence and painstaking of his consul, who, in nine cases out of ten, refers the applicant to the civil tribunals, where no sane man would venture a law-suit unless he resolves to settle down in the country ten or fifteen years to await an uncertain issue. The workmen are generally competent but careless, and demand constant supervision. This is most difficult to obtain; and Mr. Stevens mentions that very recently he refused to assist Russians to obtain Englishmen for ship-building and other purposes, from experience of the shabby and scanty treatment palmed off upon all foreigners. No native, it appears, takes a pride in his work, and his employer is equally indifferent on this point; and none hesitate to copy and mould English patented machinery and implements, not even caring, in most instances, to avoid casting the name of the foreign manufacturer, a forgery which many a landed proprietor discovers to his cost when he puts his purchase in the field; a piracy which not unfrequently brings discredit on the manufacturers in the west of Europe, and a system adopted in every factory of south Russia.

Our representative at Warsaw, Lieut.-Col. Mansfield, in his contributions to the reports, states that, in no country, perhaps, is the government apparently so indifferent to the condition of the industrial classes as in Poland, but it must be admitted also that there is but little interference. Certain regulations exist in respect of apprenticeship, and formerly various guilds had the power of exercising vexatious rights; the latter, however, have all come to an end. Strikes are unknown, and would probably be put down with a high hand. Several years since, the hands in an iron-foundry exhibited a recalcitrant demeanour, but the interference of the police was obtained, and the mechanics compelled to resume work, under the threat of worse things. Sanitary legislation does not exist; no special attention is paid to the supply of water, which is invariably drawn from pumps in the streets, or in the villages from ponds or ditches. No attempt is made at drainage in the villages; every dwelling has an open cesspool often at the door; while in the towns all drainage is on the surface, and of the most pestilential character. No regulations are in force respecting the state of repair of lodging-houses occupied by the artisan, or in regard of the over-crowding of dwellings; and there is no system of parochial relief, or of medical supervision, except in a crisis, such as a very virulent outbreak of cholera. In some of the larger industrial establishments scattered over the country, often at great distances from the towns, various arrangements have been carried out for the benefit of the hands. In most of the sugar-factories there is a medical dispensary, and in several a school for children. Complaints of over-work are almost unknown; the ordinary time is twelve hours, with two deducations of half-an-hour and one of one hour for meals and repose, giving ten hours' actual work.

As regards the purchase power of money, we learn that it is greater than in England as regards the merest necessaries of life, but for other articles the prices, owing to the tariff, are preposterous. The native and German mechanic are both satisfied with an inferior style of diet and living that would not content an Englishman, who, if prepared to make the necessary sacrifices, might probably make a more considerable saving than in his own country under corresponding circumstances. For instance, a brass-fitter or a weaver with a moderate family, and receiving eight roubles a-week (about £1 1s. 8d.), might make an average weekly saving of from 2s. to 4s., without denying himself anything which is suitable for his class—perhaps, with care, even a larger sum. Owing to the extreme dryness of the climate, it is more or less necessary to follow the diet of the natives of Poland and Russia, and to eat daily a portion of black bread, and use various aliments containing vegetable acids, such as sour and cabbage soups, pickled vegetables, &c.; neglect of the above produces a tendency to scrofula, more especially with young people. With regard to the quality of the work produced, it may be assumed that the Polish manufactures are considered to be better, more durable, and to possess a superior finish, when compared with what is produced in the rest of the Russian Empire: and that such is the case is demonstrated by the circumstance that, at the exhibition held recently at St. Petersburg, out of 1,990 exhibitors, 240 came from the kingdom of Poland, and 122 received prizes or were favourably mentioned.

In most factories, the rate of wages is determined after a few days or weeks' probation, and every opportunity is afforded to careful and industrious workmen to obtain a fair and liberal remuneration. The only careers, however, in which there would be the smallest opening for the British artisan and mechanic are the woollen and cotton factories, and the metal works. At the present moment, the demand for labour in these branches is amply provided for, and no Englishman would do wisely to seek employment unless in answer to a definite application on the part of a manufacturer. The German workman has attained a permanence and a position in Poland from which it would not be easy to displace him. He has the advantage of language, German being pretty generally understood among the business people; he is thrifty, and less difficult in his mode of living than the corresponding classes in England

and comparatively close to his own country. On the other hand, English workmen, if they give satisfaction, are highly prized, and can command excellent remuneration; they meet with no ill-will or jealousy on the part of their fellow-workmen, and when already some time on the Continent acclimatised to foreign habits, they frequently make a prosperous career in Poland.

Brazil.

Mr. T. C. Cobbold, writing from Rio de Janeiro, observes that few English labourers are at present employed in this province. The workmen engaged in road-making, construction and repair of railroads, and for agriculture, are for the most part Portuguese, who, being very economical and sober, contrive, with a daily pay of from 3s. to 4s., to economise at least the half. The Company Uniao and Industria, which is a large employer of labour in road and railroad making, and in some kinds of cultivation, also waggoners, drivers, and mechanics, pay their workmen on the railroad from 2,000 to 2,400 reis per diem.; their waggoners, and those employed in cutting grass, &c., 30 to 40 milreis a month, and their food. The mechanics of this company, employed in their workshops at Juiz de Fora, earn wages varying from 2,500 reis to 4,500 reis per diem. The latter are all German, as are also the coachmen and some of the road labourers. The less enervating highlands of the mining districts are better suited to the Englishmen, and especially to the Cornishman. In June, 1867, there were 86 miners and 55 workmen and mechanics employed at the Morro Velho mine, where, being well paid and cared for, they ought to be able to put by considerable sums of money. It is difficult to estimate the exact relative value of money, with reference to the position of the labouring class, in two countries in which not only prices but commodities, and, above all, requirements differ so essentially, as in the present case. On the whole, however, there can be little doubt that, upon equal money wages, the real remuneration obtained by an artisan in this country would be inferior to that received on a like footing in England. It is, in fact, doubtful whether an English mechanic would not enjoy as much comfort on £15 per month in his own country as on £20 per month in Rio de Janeiro.

The population of the two extreme northern provinces, Para and Amazonas, according to Mr. Consul Drummond-Hay, is composed of several distinct classes or races of man, namely, the Tapuyo (or civilised Indian), the white man (descendent of the Portuguese, Europeans, and foreigners from all countries), the negro, and, lastly, the several lineages which have sprung from the free mixture of all these races, and amongst whom, especially in the lower orders of the towns, black blood appears to predominate. The immense area included in these two provinces may be roughly computed at about 400,000 square miles, and the existing population at not more than 350,000. The proportion of slaves is small as compared with other provinces in the empire, hardly amounting to 20,000. Their number is yearly decreasing, for nowhere in Brazil is the feeling that the abolition of slavery is necessary and imminent greater than in those provinces. The proportion of available labourers is very small, probably about one-tenth of the population, as, though there is some poverty, there is little suffering, for nature is prodigal, though men are inert; yet, from this very cause, is the want of labourers in the fields and towns severely felt; labourers and workmen are clamoured for, enabling the few to make up, to a certain limit, their own daily, and often exorbitant, stipulations for wages. The European who emigrates to this country, and by temperate habits becomes acclimatised, competes successfully with the native, suffering no further ills from the climate than others of the white or dark race who are born and bred here. So far as agricultural labour is concerned, should proper encouragement be given, by the offer of good land and other early conveniences, to the gradual and voluntary immigration of an industrious race, who would not allow the extraction of rubber, or the simple gathering of nature's produce to absorb their attention over all other labour, there is no doubt that, in the course of a little time, comfort and wealth would be enjoyed by the production of cotton, sugar, rice, cocoa, and other numerous articles indigenous to these provinces, and the condition of a country yet in the very infancy of civilisation materially enhanced. Food, or the necessary aliment of man, is cheap and abundant, but luxuries are dear, being double and treble the price in England.

There are no manufactories on any large scale. Cotton is neglected, and the small manufactories, for bricks, soap, or the like, for home consumption, or, again, workshops and workmen, are all yet in the very cradle of progress, and offer little assistance for forming correct statistics as to class, workmanship, or bodies of workmen. Wages vary from 5s. to 8s. 4d., and even 11s 9d. per day. The regular hours of labour are usually from six in the morning till four in the afternoon, from which time one hour or one hour and a-half is taken for a mid-day meal.

Mr. Drummond-Hay observes that any intelligent, skilful, and sober artisan would be, and is certain of remunerative employment in Para. He would have difficulties at first to contend with, such as the language, house accommodation, and occasional slight illnesses, until he became acclimatised and accustomed to the usages of the country. But if he were a persevering man, not wasteful in his expenditure, not too urgent in his want of society, and lived with regular, quiet habits, avoiding the many vices which affect strangers in Para, he would, as a rule, be able considerably to better his circumstances, and rise in a brief period in reputation even above his class in England. Unhappily, however, the greater portion—not the whole—of English artisans who have hitherto appeared, seeking employment, have been sadly wanting in some of these qualities, especially in their extraordinary addiction to drink, and, in consequence, have but in few cases realised their wishes or reflected credit on their countrymen resident in the place, who feel such discredit in their daily intercourse with Brazilians and natives of other countries, who are generally of far more temperate habits.

Peru.

The purchase-power of money in Peru is stated by Mr. Mathieson, the manager of the Lima and Callao railways, to be not more than one-half what it is in England; provisions, lodging, wearing apparel, and, indeed, all the necessaries of life, are much dearer than at home; washing is also an expensive item, and the high rate of wages is so far modified by the greater cost of living. Much may be done, however, to lessen this disadvantage, by workmen bringing out clothing and other articles from England in sufficient quantity to serve them during the period of their agreements. These contracts are usually for three or four years, with the condition of free passage to the coast, and passage home again, should they determine to return at the expiration of their term. If a workman brings a good outfit with him, and is provident and temperate in his habits, he can always save. Assuming that a mechanic receives four dollars (12s. 2d.) per day, his expenses, in food, lodging, &c., will be about sixty dollars (£9 2s. 6d.) per month; he can thus lay by at least forty dollars (£6) per month. This refers to men who provide themselves with board and lodging. In some instances the agreements made in England with mechanics includes the items, the employers finding the workmen with dwelling and board, and the wages, of course, are subject to a corresponding reduction. The largest employers of English workmen are the Pacific Steam Navigation Company. They have, in their factory in Callao, 150 skilled mechanics on an average, who are lodged and provisioned on the premises. The arrangements made for the health and comfort of these men are admirable in every respect. The contracts are usually for three years, in some cases four years, with passage out, and house at the expense of the companies. The rate of wages vary from £120 to £144 per annum; and assuming £130 as the average pay, these men may, with prudence and care, save from £80 to £90 a-year, provided they have with them a sufficient stock of clothing for the term of their contract. The gas and water companies of Lima and Callao, which are under English management, adopt to some extent the system of providing their workmen with house accommodation and food. Arrangements of this nature are favourable to the men, for the reduction in wages is fully compensated by the advantage of good and healthy lodgings, and the care and supervision exercised as to the diet and living of the workmen. There seems, however, no reason to believe that the power of preserving the health in this climate is, under ordinary circumstances, less than it is in England, provided temperance and sobriety are adhered to; but when attention to these is neglected, health and vigour decline more rapidly than in England. The climate of Peru is very benignant, and is favourable to out-door work; but much exposure to the sun is injurious and debilitating. The diet of the workmen is about the same as in England, except, perhaps, during the summer months, when there is less inclination for animal food. Spirits and stimulants of all kinds are hurtful, and they are not needed, for a mechanic can do as much work, and can undergo as much exhaustion without serious risk, as he can do at home, provided he eats good, wholesome food, and abundance of this can always be had in Lima.

Persia.

From the opinions expressed in the reports from Ispahan, Shiraz, Koum, Hamadan, and Kermanshah, and from the views of those most competent to decide upon this subject, Mr. Jenner, writing from Teheran, states that he is led to express a positive judgment to the effect that no immigration of workmen seeking employment as individuals would lead to anything but disappointment and ruin. With the exception of one or two branches of industry, such as the manufacture of carpets and shawls, in which the Persian workmen excel our own, there is no demand for skilled labour. One or two workmen from each craft might succeed in making a fortune, if they would induce their employers to pay them; but a dozen or two would glut the market. There is, however, one

way in which an emigration to Persia might be profitable to those engaged in it. Self-supporting colonies, composed of 500 to 1,000 or more members of both sexes, might thrive, if engaged either in working some of the numerous mines to be found scattered all over Persia, or in mannfacturing cotton stuffs of quality corresponding to that of the chintzes which form the chief article or importation to the country, or silk stuffs for use and exportation, for both of which manufactures the raw material conld be procured in abundance and at cheap rates npon the spot. Colonies engaged in these or other pursnits, and so constitnted, like those of Germans in Odessa, or of Swedes and Norwegians in the United States, as to be enabled to till their own land, make their own roads, aud provide in every respect for their own wants, would, in the opinion of many persons qualified to judge, be likely to meet with success. Before such a colony can be established, it will be necessary to overcome many prejudices on the part of the rulers, which at present are so deeply rooted as to render success almost hopeless. From the people, far from meeting with opposition, Mr. Jenner believes such colonies might expect the welcome everywhere bestowed upon those who lower the prices of food, and increase the valne of labour.

When the winter diet of the workman consists almost entirely of bread, rice, and bad cheese, with a small quantity of tea, in the form of a decoction, and the summer diet of bread and *sayfi*, or summer produce, *i.e.*, melons, cncnmbers, vegetable-marrows, egg-plants, and various forms of edible gourds, it would be idle to compare the purchase-power of the wages with those paid to English workmen. In Persian towns, large caravanserais, built in former times to accommodate a far more nnmerons popnlation, are generally to be fonnd; these buildings, though generally in a more or less ruinous condition, can still furnish shelter for a large number of workmen, whilst the court yards of mosques, and sheltered corners in various parts of the town, are the refuge of a large nnmber of the still poorer classes. In the manufacture of shawls and carpets, in brass work, in enamel, in gold or silver, in every species of ornamental work where a good effect is sought for rather than excellency of finish, the Persian work may be said to be good. The ignorance of the workmen in many other branches is not altogether the result of their want of opportunity of improvement. The love of tradition is very strong, and the only change to be noted is that which is prodnced by the gradnal deterioration which, by a universal law, comes upon nations which do not progress. No artisan takes a pride in excelling in his work. The laziness of the Persian character is so great, that the workman can never be brought to do more than what is sufficient to earn the price of his labonr. There is, however, one nnmerous and powerfnl fraternity which is never tired of attempting to snrpass. Those who belong to it, and they form in two or three instances the population of entire districts, are ever striving to excel; they devote every leisure moment to this purpose, and are stimulated to constant endeavours by the fame of those who have attained to eminence in their difficult art. Few Persians of any position bnt have arrived at a certain skill in this accomplishment; and prime ministers, and even sovereigns, have owned the greater portion of their celebrity to their extraordinary aptitnde in penmanship. The Mnrzas are the only "class of workmen who take a pride in their work, and endeavour to excel from the sense of honour they have in executing it." Mr. Jenner remarks that, to say that the chief artistic talent of Persia is applied to such a purpose, is equivalent to saying that it is directed to the least profitable channel it could possibly pursne. If the years of constant stndy and patient application wasted upon this thankless pursuit were bestowed upon any other art, science, or even handicraft, Persia might hold a high rank amongst civilised nations.

Mr. Consul-General Herbert, writing from Bagdad, states that, so far as he can learn, from careful inquiry and general estimation, the artisans and industrial classes bear the proportion of about 60 per cent. to the other classes. The latter may be said to comprise government employés, ulemas, landholders, merchants, petty traders, dependents, and beggars. The former are armourers, bakers, barbers, blacksmiths, bleachers, boat-builders, boat-trackers, bookbinders, braziers, bricklayers, butchers, carpenters, coppersmiths, dyers, embroiderers, engravers, farriers, goldsmiths, locksmiths, matmakers, muleteers, needlewomen, pipemakers, porters, potters, shoemakers, spinners, tailors, tanners, tinmen, water-carriers, watchmakers, weavers, &c., and field-labourers. As regards the nature of their engagements with their employers, there is no investment of capital in their case—no manufactories. A master artisan works himself with his journeymen and apprentices; the labour-market is well supplied, and artisans are, for the most part, so comfortably provided that they are indifferent to extra work, and are content with that which they know must come to them. They are nnwilling on any occasion to hurry themselves, or pnt themselves ont of their way, to accommodate a customer. Mr. Herbert is of opinion that there is no opening at present for the introdnction of foreign labour, and that English artisans and workmen shonld not be encouraged to come independently to the conntry. But the most promising openings are opened for capitalists, both agricultnral and commercial; and should it be possible to attract to it the attention of such, their service would offer occasions for the employment of Englishmen as snperintendents, engineers, overseers, and skilled workmen, and probably, in the course of time, for that of subordinate workmen and labourers. Under the present law, foreigners can hold land in the Ottoman dominions, and should it be possible to direct the attention of monied enterprise to this part of them, there can be no doubt that, when rapid and easy communication may be established with east and west, as may be hoped in a few years, shonld her Majesty's government, in concert with that of the Porte, encourage the scheme of a railway to connect the Mediterranean Sea and Persian Gulf, large fortunes are to be made. Persons or corporate bodies investing money in land would need machinery for irrigation, tillage, for preparation of cotton, fibres, &c., and wonld necessarily employ Englishmen, and, as their works advanced, the nnmbers of these would increase iu a corresponding manner.

REPORT OF THE COMMITTEE ON WASTE IN COMBUSTION.

(*Concluded from page* 261.)

Advancing from the utilisation of the gases and the heat prodnced in the fnrnaces, we arrive at an application of the regenerative system, which appears to have been first attempted by the Rev. Dr. Stirling in 1817, and subsequently by Mr. Ericson in his caloric engine. The first witness examined before this committee was Mr. C. William Siemens, whose name is most honourably associated with the applicatiou of this principle in the form of the regenerative gas furnace. The principles involved are well described in the evidence given. Essentially the coal employed is converted into its gaseous constituents, cousisting, "for the most part, of carbonic oxide mixed with light carburetted hydrogen and some pure hydrogen, and these combustible gases are mixed with nearly 60 per cent. of nitrogeu and with vapours of water." This gaseous and vapour mixture passes into the "regenerating chambers" (which are arrangements of fire-bricks which have been already heated to 1,000° by the escape of the hot products of combustion from the furnace itself), aud they thns arrive at a high temperature before entering into combustion, so that at once a flame of great intensity results. In proof of the advantages of this system for steel melting, Mr. Siemens states the practical resnlt to be "that 12 cwt. of coal suffices to melt a ton of steel, whereas in the ordinary furnace at Sheffield about three tons of Durham coke are necessary to accomplish the same end." This is to a great extent confirmed by the report given by the Monkbridge Iron Company, Leeds, by Vickers, Sons, and Co. (Limited), River Ironworks, Sheffield, and others. A letter from Vickers, Sons, and Co. will be found in the appendix, which is followed by a list showing the increase in the number of Siemens furnaces for iron and steel manufacture, glass making, smelting metals, &c., from 1862 to 1870. From this list, and the following summary, we see that there was a very large increase between those years, showing, convincingly, that the economy of those furnaces is appreciated.

1862.		1870.
14	Reheating and puddling furnace	411
17	Steel furnaces	112
7	Plate glass	36
12	Window aud bottle glass	38
14	Flint glass	44
	Muffles	37
3	Gold, silver, and other metals	93
8	Gas works	46
—	Mint	50

Upon the advantages of the regenerative system, we find Sir William Armstrong saying, at the British Association, in 1865. "The regenerative furnace arrests a large portion of the fugitive heat, and adds it to the gaseons fuel which snpports the combustion of the furnace * * * The regenerative gas furnace not only prevents waste of fuel, but it also prevents smoke."

We have, in commencing this report, referred to the theoretical value of coal as a producer of heat force. This question was especially the snbject of inquiry in the examination of Mr. Siemens. The inventor says, "I believe that virtually there is a perfect combustion in the gas furnace, unless it is mismanaged." That is, this furnace secures a complete conversion of the carbonic oxide into carbonic acid, and the regenerator absorbs from, and again gives out, to the prodncts of combustion the highest practical quantity of heat. There is a loss of heat in the gas prodncer, and a loss also in the regenerative gas furnace, bnt still for all purposes there appears to be a saving of fuel, which amounts

in many cases to nearly 50 per cent. The cost, however, of erecting the regenerative gas furnace is rather more than double that of the ordinary furnaces.

We have the evidence of Mr. Menelans that in puddling furnaces the present plan of burning fuel "is very barbarous indeed," and that great advantages are to be expected from the adoption of Siemens' plau for puddling. "You wonld get a more perfect eombustion in the furnace, and you wonld regenerate nearly the whole of the heat which you now send up the chimney;" but this witness thinks if the waste heat of those furnaces is utilised by applying it to the production of steam that there is not really so large an economy as that which is claimed for the regenerative system, as compared with puddling and reheating furnaces, the waste heat from which has been utilised.

In the first place, we have the combustion of the coal carried forward in immediate contact with the metal, and the gases produced are allowed to pass off at snch a temperature that immediately they come iu contact with the oxygen of the atmosphere, as at the top of the chimney, they burst into flame, and all this heat is lost. In the second condition the gases escaping from the furnace are caught at their very high temperatnre, and used in producing steam; while in the third plau the coal is converted into gas and vapour as in the first operation; it is united with the required quantity of atmospheric air to secure perfect combustion in the furnace, and the heat produced in passing through the regenerator is retaiued for future work, except that when the products of combnstion reach the chimney they have a temperatnre of 200° above the atmosphere.

It must be remembered that of the 6243 pnddling furnaces at work in 1869 a very small uumber of them had adopted any arrangement for utilising the waste heat, consequently, even at the lowest estimate, the loss of heat must be enormons. The tendency, however, to utilise this heat in many of our largest and best conducted establishments (as, for example, at Dowlais where the waste heat of the pnddling furnaces is used for raising steam for the Bessemer converters) is such that we may safely predicate that within a few years the arrangements for utilising the heat produced in the furnaces will be rather the rule than the exception.

In the second examination of Mr. Siemens he drew the attention of the committee to a yet further economy in the use of his system in the improvement of the metal, and in an increaso of 12 per cent. in the quantity obtained, this increase being derived from the oxide of iron used in fettling (lining) the pnddling furnace.

In immediate eonuection with this subject we must notice the furnace designed for burning coal in a state of fine powder which has been introduced by Mr. T. Russel Crampton, who was examined before this eommittee. For some time one of those furnaces has been in action at Woolwich, and recently one has been worked, in immediate eonnection with three other reheating furnaces, at the Bowling Ironworks, Bradford, Yorkshire. At these works the furnace was examined in action by the ehairman of this committee, and some of the experimental trials with this furnace were seen by other members of the commission. There has not been a sufficient length of time since any of Mr. Crampton's furnaces have been in practical use to determine its real value. The results, however, have been sufficiently satisfactory to enable us to see that a perfect combustion is effected, that the heat obtained is under control, and that there is an absence of smoke. We learn that, in addition to the furnaces named, several others are in process of building, so that the economic value of the principle will be determined within a short period. The advantages claimed by Mr. Crampton are, first, the utilisation of the small coal; second, economy in constrnction of furnace; thirdly, the perfect combustion of the fuel; and fourth, the controllability of the heat.

Althongh the small coal is now utilised in various ways which were formerly disregarded, still there is considerable valne in any new process by which it can be still further employed. The report of Committee E will show how large a qnantity of small coal is produced in the conntry. The cost of reducing the small coal to a state of fine powder as required for Mr. Crampton's furnace—sifting appearing to be necessary to secure good results—is an item of some importance.

In addition to the cost of constructing the furnace, there is the cost of the gearing, and of the arrangements necessary for blowing the powdered coal, in regulated streams, into the furnace, upon which the perfect combustion of the fuel depends. But with every allowance in respect to those matters, it does appear that Mr. Crampton's mode of burning coal promises to realise a great economy. The evidence deals fully with the principles involved; it is not necessary therefore to repeat them here.

The economical valne of the Bessemer process for the production of steel necessarily claimed attention. Mr. Henry Bessemer was before the committee, and from the evidence given by that gentleman it appears that not less than 150,000 tons of steel are made by his process within the year, which will represent a saving in fuel of above half a million tons of coal. This is not the place to dwell on the value of the Bessemer process as a means for the production of steel of high value with considerable economy. Still, wheu we find that steel rails can be substitnted for iron rails, aud that eleven iron rails, have beeu worn ont on both faces in a fair experimental trial, whereas the steel rail was still wearing upon the first face, thus actually saving twenty-three iron rails, involving the saving of the coal which would be used in the prodnction of that quantity of puddled iron, the cousideration cannot be neglected. There are other instances, for which we refer to the evidence, in which the Bessemer steel is made with advantage to take the place of iron, and, as iu the case of the rails, to effect a saving of coal in mannfacture. The production of very high temperatures by means of a condensation of the gaseous prodncts of combustion within the fnrnace was referred to. The experiments which have been made appear to promise well, but at present the results obtained have been those of comparatively small experiments only.

Smelting of Metals other than Iron.

Turuing to the other metallurgical works of this country, we discover evidences of ecouomy in prodnction, though not to the same extent as is shown in the manufacture of iron.

In the smelting of tin one advance was made many years since by substituting for the old-fashioned blowing honse or blast furnace the modern reverberatory furnace. We find that abont twenty years since $3\frac{1}{2}$ tons of coal were consumed in prodncing two tons of white tin. At the present time one ton of coal is equal to the production of a ton of metallic tin.

In copper smelting we find that when MM. Dufrenoy and Elie de Beaumout visited Wales in 1822, 20 tons of coal were used in producing one ton of fine copper from ores yielding $8\frac{1}{2}$ per cent. of copper. Dr. Percy informs us (1859) that "from 13 tons to 18 tons of eoal, which now costs 5s. a ton, are required to make one ton of copper, aud about half of this quantity is consnmed in the first and second operation of calcining aud melting. A mixtnre of three parts by weight of free burning aud one of binding eoal is employed."

Again, the same authority writes, "For every ton of eopper made from a mixture of ores yielding 10 per eent. of copper 18 tons of coal are consumed."

We have the valuable evidence of Mr. H. Hussey Vivian, a member of the commission, to guide us in our consideration of the economy effected in this special metallurgy. From this we learn that the average consumption of coal, taken over eighty-five weeks in the four years before 1856, was 24 tons 6 cwt. per week per furnace, whereas the present consumptiou (1869) is but 18 tons 7 cwt. 2 qrs. per furnace per week, showing thus a saving of six tons nearly upon each furnace every week. This economy was referred to the improved construction of the grate; the more recent grate having a much less depth than the old one. The evidence gives very fully the structure of the grate to which this economy is due, and to it we therefore refer the reader. The improved result is due evidently to the fact that the eoal is more completely exposed to the action of the air, and therefore undergoes more perfect eombustion in the shallower than in the deeper furnace.

The arrangement of these copper furnaces are proved—according to the evidence of Mr. Vivian, who has had many years' experience with them— to be as satisfactory as any of the regenerative gas furnaces, and far less costly. "My impression is," we quote Mr. Vivian's words, "that if the system adoped for firiug copper furnaces were adopted in all cases of reverberatory furnace a very considerable saving of eoal would be effected." In addition to this economy in smelting the copper ore, the introduction at the works of Messrs. Vivian and Son of the Gerstenhoffer furnace for roasting the copper ore (copper pyrites) saves nearly the whole of the coal originally used in calcining the ore. In this arraugement the combustion of the sulphur of the bisulphide of copper is maintained by allowing tho oro in a state of fine division to fall in a continuous shower through the heated furnace. For eighteen months a Gerstenhoffer furnace has beeu constantly maintained iu action without interruption. The quantity of coal used in calciuing was not large, but by this arrangement it is saved, and a great quantity of sulphuric acid obtained.

In the metallurgy of lead and in the desilverising of lead there have beeu some improvements, leading necessarily to the saving of some fuel, yet within the present century this does not appear to have been large, notwithstanding the general adoption of the process of Hugh Lee Pattinson for desilverising lead. At this time abont a ton and a-half of coal appears to bo used in the smelting and desilverising of a tou of lead. Many experiments—and some of them appeared at first to be of a promising character—have been made to simplify the troublesome and expensive arrangements which are now employed for the prodnction of

metallic zinc, which are essentially dependent upon a carefully conducted process of distillation.

Attempts have been made to reduce the ores of zinc in an atmosphere of carbonic oxide produced in a blast furnace. It has been done, but the difficulties, and consequent uncertainties, surrounding the operation has led, at all events for the present, to the abandonment of all experiments in this direction.

Large economies have been realised by attention to the operations of smelting zinc with the Silesian and the Belgian furnace. Mr. Vivian informs the committee that twenty-seven years since 30 tons of coal were used in smelting blende (sulphide of zinc), and producing a ton of metallic zinc. Of this 10 tons were used for calcining the ore. The Silesian furnace now uses 10 tons of coal per ton of zinc, and the Belgian furnace does not use more than six tons per ton of zinc, if the ore be moderately rich.

The application of the regenerating gas furnace promises yet further economy. The committee are told that at one firm using the Silesian furnaces and the Siemens arrangement a saving of 40 per cent. has been practically realised. Beyond this, the number of retorts which can be placed in one furnace are doubled, and the yield of the metal zinc is considerably increased.

Glass, Pottery, Bricks, &c.

The other manufactures which require the use of coal exhibit in a similar degree to those already mentioned that general tendency towards economy which has prevailed during the present century. Beyond this we find that Siemens' regenerative process has been carried out with advantage in plate glass and other works. At Jeumont, we are told, there is a saving of 6,000 kilogrammes of coal, or nearly six tons, in the twenty-four hours. We learn also that the introduction of the Siemens, furnace into the window, bottle glass, and flint glass manufactures of this country, and more especially of continental works, has been attended with great saving of coal. The introduction of Hoffman kilns for burning clay goods has certainly effected a saving of coal in those manufactures in which they have been adopted, but, mainly owing to the first cost of building them, they have not been largely adopted. At present there are about eighty of those kilns in Great Britain. The following statement will show the advantages of those kilns :—1,000 bricks, ordinary 9in. by 4½in. by 3in., in open forge, fire open kilns, use 12 cwt. coal; Scotch kilns use about 10 cwt. coal; square Scotch kilns, arched top, with fire-boxes, 8 cwt. coal; in close clamp, about 4 cwt. slack; Hoffman's kilns use only 2½ cwt. of "smudge."

Lime.

A ton of lime requires about 12 cwt. or 12½ cwt. and slack; one-half of each. Running kilns sometimes use coke. Hoffman's kilns for lime use from 2 cwt. to 2½ cwt. of smudge to the ton of calcined lime.

The Production of Steam Power.

We have already alluded to the production of steam power; but, before passing on to the examination of the evidence given before the committee, we feel called upon to notice the enormous waste of heat, and consequently the wasteful consumption of fuel, in a very large majority of steam boilers used in this country, most especially such as are used in collieries and ironworks, through their being left to the influence of every change in the atmospheric conditions, quite exposed to winds, rains, and snows, when a slight covering of a non-conducting substance would, by protecting them, improve their steam-producing power, and save a considerable quantity of coal. The careless and wasteful manner of stoking in most of the coal-producing districts is not only a source of vast waste, but of extreme annoyance to all the surrounding neighbourhood. Coal is piled upon the fire without any discretion, producing dense volumes of the blackest smoke, which is so much fuel actually thrown away. Nor is the waste the worst part of it; vegetation is destroyed or seriously injured for miles, and that which acts so seriously on the plant cannot fail to be injurious to man. Dirt, disease, and indirectly immorality, following like evil spirits in their dark train, are the natural consequences of that carelessness which marks the manufactories of the coal districts. On this point one witness, Mr. Anderson, of the Royal Arsenal, remarked, "My experience is, that where coal is cheap the system of stoking is a very careless one, but that where they have to pay dearly for their coal, as, for example, in Cornwall, the system of stoking is exceedingly good. Placing the coal immediately within the furnace door, it undergos the process of coking, and the whole matter which passes over the heated coal is consumed." One of the commissioners asks a witness if there is not "a prodigious field for improvement in that direction," meaning the consumption of coal for raising steam. The reply of the witness, a man of great experience, was, "No doubt of it." Without travelling beyond known principles, it was thought that a considerable saving of fuel could be effected. Imperfect combustion must be regarded as the first essential loss. The air is supplied so unskilfully that much passes into the chimney as hot air, carrying with it the vast quantity of unconsumed carbonaceous matter which we see escaping in black clouds from the top of the chimney. This imperfect combustion may be traced to the bad construction of the fireplaces, and to the reckless way in which coal is thrown into and over the mass of ignited matter in the fireplace. Sir William Armstrong in his evidence states that we do not utilise in the best steam engine much more than one-tenth of the theoretic power, and in common high-pressure steam engines we do not utilise more than about one-thirty part of the power of the coal. Again, that, with the average run of steam engines, their duty is so far below the duty of the best steam engines that three times as much coal is used as is actually necessary. We refer to the evidence of Mr. John Hick, M.P., where he described the action of the Corliss engine, in which, by its careful construction and a good system of steam jacketing, a saving of something like 30 per cent. is said to be effected. The question of steel boilers in the place of iron ones was considered, and this witness considers that the use of steel in boilers has many advantages. The ordinary two-flued "Lancashire boiler" is reported to save 20 per cent. when made of steel, the only difference being in the metal, and in the consequent thickness of the plates—the steel plates being one-third thinner than the iron ones. The steel boiler, presenting a smoother surface than iron, does not allow the lime deposited from the water to adhere, there is therefore no incrustation, and "as to their durability (steel and iron boilers) there is no comparison between them." We have it in Mr. Hick's evidence that with the Corliss engines, with condensing apparatus and steel boilers, that 2½lb. is the indicated horse-power per hour, against 7lb. in the old non-condensing engine. The ordinary consumption of coal being taken at from 7lb. to 8lb. or to 9lb. per horse-power per hour for non-condensing engines, it is thought that with improved engine and boilers it might be reduced to 5½lb. or 6lb. of coal, and that a condensing engine, using from 4lb. to 5lb., can be brought down to 2lb. or 2½lb. Upon the same point Sir Wm. Fairbairn gave it as his opinion that we are far short of the pressure which is necessary to effect economy in the production of steam. "I should go up to 150lb. or 200lb. upon the square inch in order to effect a larger system of expansion." To use such high pressures the locomotive form of boiler must be adopted, or boilers of smaller diameters, and consequently improved construction. Mr. E. A. Cowper explained to the committee his system of steam jacketing. The conclusions to which the evidence of this witness lead are much the same as those of the other witnesses. He regards 7lb. as the average consumption of coal per horse-power per hour, it being in many cases as much as 10lb.; and he says "There are engines burning as much as 11lb., and I am sorry to 12lb.; but, by the adoption of combined high and low-pressure engines, with proper jacketing, that consumption might be reduced to 2·2 lb." We have also the evidence of Mr. J. Anderson, of the Royal Arsenal, Woolwich, bearing on the same point. This witness, as we have already noticed, lays much stress upon our present imperfect system of stoking, and on the saving which could be effected by having a better class of men employed, and by holding out inducements to them to economise coal. The general impression derived from Mr. Anderson's evidence was that he thought we had by no means arrived at a satisfactory point in the generation of steam; that a more exact education was desired for our younger engineers, especially of a knowledge of that branch of philosophy which deals with the convertibility of motion and heat. He thought our education was not so far advanced as that of the German and French engineers, and that the influence of this education was seen in "the points of economy in many of the foreign engines" in the Paris Exhibition of 1867. Better stoking and better special education would, it was thought by this witness, lead to a vast saving in the consumption of coal in the future. On the same subject Mr. David Thompson, mechanical engineer, gave much useful evidence. Mr. Thompson referred the improvements which had been steadily going on for many years to an increase of pressure in the boiler, and carrying out to a greater extent the system of the expansion of the steam. If he were allowed to use his own judgement in the construction of pumping engines he should certainly use at least double if not treble the pressure now generally adopted. The pressure being now on the average about 40lb., he thinks there would be no difficulty in obtaining 100lb. pressure, and the result would be greatly increased economy. This witness drew attention to the greatly increased economy of coals in the production of steam in ocean steam vessels. From the circumstance that the carrying of coal for long voyages, and from its greatly increased cost at ports distant from coal-fields, a rigid economy of fuel is pressed upon all concerned, thus confirming the general view that the strong inducement to the economy of coal will be the increased cost of it. Mr. Lavington E. Fletcher, the engineer to the Manchester Steam Users' Association, has about 2,000 steam boilers under his inspection. He estimates the number of boilers in the kingdom as being considerably above 50,000, but he does not see "any rapid improvement" in them as it respects the

economy of coal. A considerable portion of this witness's evidence went into the structure of boilers and the causes of steam boiler explosions. Much of this was of considerable importance, but as it bore only collaterally on the consnmption of coal, we prefer referring directly to the evidence. In direct answer to the question whether there is in progress a system of economy which is likely to be continned in future, Mr. Fletcher replies tbat 7lb. or 8lb. of coal is the quantity now consnmed throughout the kingdom per horse-power per hour, but there is certainly a gradnal and steady improvement, "but it will be a matter of time; the improvement will be as much a matter of general ednecation as of simple mechanics." Mechanical firing was referred to by this and other witnesses, the general impression being that in large works it would prove economical, but not so in small manufactories. On the consumption of smoke, Mr. Fletcher questions if practically smoke can be completely prevented with economy. This is confirmed by the inquires which have been made in the large mannfactnring towns. It appears difficult to extinguish the last vestige of smoke without diluting the last few atoms of carbon with more oxygen than is required, and therefore the advantage is lost by the superfluous amount of cold air admitted. Notwithstanding the probable fact that it may cost a trifle more to burn the smoke in a special manufactory, there must surely be a vast economy in freeing such towns as Manchester, Leeds, or Bradford, from the deluge of solid carbon which is deteriorating every work of nature and of art. Ou the question of Galloway's tubes this witness was examined. The general impression was favourable to their application, as has been already stated, bnt they are thonght to be only a convenient mode of increasing the boiler snrface. "Fuel economisers," as they have been called, of various descriptions, which consist mainly of a series of tnbes containing water placed in the stack, so as to be heated by the waste heat from the fire, were inquired into. There was no doubt but that these arrangements tended to economy. "If we could heat the feed of the boiler as high by the waste steam as by the waste heat from the fire there would be no advantage in using this apparatus; but if we can raise the water to a higher temperature by this arrangement than by the waste steam there will be an advantage." Those arrangements mnst be considered as plans for obtaining an extension of boiler surface. The evidence of Mr. Charles Greaves, of the East London Waterworks, goes to confirm all presions evidence that economy has been produced in raising and nsing steam by the use of a higher pressure of steam than was formerly attempted. This witness does not see the promise of auy great degree of economy in the higher class engines of any sort. "There will be a considerable economy as the style of engineering improves among engines in general." But Mr. Greaves conceives economy may arise "either from an increase in the price of coal, or from a better diffnsion of engineering knowledge and engineering principles." He thus confirms the replies of other witnesses, that we can only hope to save coal, in the future, by an extended and a better system of scientific educatiou. Mr. Thomas B. Jordan favoured the committee with a description of his combination boiler. The great advantages are the facility with which all the parts of the boiler can be moved, the boiler put together and erected, and the rapidity with which steam can be raised iu it. With this boiler the general consumption would be about 5lb. per horse-power per hour. The nse of liquid fuel has been fully considered by the committee, aud the correspondence and evidence go to show that there are many objections—by no means insuperable—to the use of petroleum and paraffiu oil for a fuel for the production of steam. We have seen the "dead oils" from gasworks bnrnt in steam boilers with great apparent economy, aud no doubt there are conditions under which the liquid fuels may be used with advantage to the saving of other fuel. At oue of the meetings of the committee the question of the utilisatiou of the heat wasted in burning coke was considered. It appears that at Seraing in Belgium the heat of the coke ovens is utilised for raising steam. The evidence of Mr. I. Lowthian Bell npon this point went to show that, although there was an undoubted economy to be obtained by nsing the heat of the coke oveus, yet there were practical difficulties which stood in the way of the adoption of any plan at present for this purpose. Attempts are making to coke several varieties of the small of coal not usually regarded as coking coal, as, for example, that of South Staffordshire. In that district, too, arrangements for cleaning the coal are used, and promise some considerable saving. It must not be forgotten that the small coal of South Staffordshire is used under every disadvantage, being mixed with a large proportion of shale and incnmbustible earthy matter. The authority of Sir Daniel Gooch was brought before the committee in a letter from that gentleman to the effect that 8lb. per horse-power per hour might be regarded as the result of the bnrning of coal to prodnce steam in all cases in Great Britain, and that good railway locomotives do not consume more than 3lb. per horse-power per hour. Sir Wm. Fairbairn remarks, "With regard to the locomotive, I have a very strong opinion that we are not able to do much in the way of economy in that direction." The saving, however, that has been lately effected by the use of coal instead of coke is considerable. As mnch power is now obtained from one pound of coal as was got from one pound of coke, the cost of the former being bnt little more than half that of the latter. We have it in evidence notwithstanding that, though the limits of economy are nearly reached in the use of fuel in the locomotive, that on the south-Western Railway the substitution of coal for coke has effected a saving of not less than £30,000 a year. We also learn that upon most railways the quantity of coal used iu the locomotive engines varies from 38lb. to 45lb. per mile, whereas by arrangements introduced by Mr. Joseph Beattie it has been redneed on the railway of which he is engineer to 25lb. per mile. The quantity of coal used in the United Kingdom for domestic purposes, and manufactures other than iron, is about 60,000,000 per annum; the manufacture of iron consuming between 30,000,000 and 35,000,000 tons. Nearly three tons of coal are nsed—omitting that employed for the manufacture of iron—for all purposes, by each head of the population; or for domestic purposes only, about one ton per annum for every man, woman, and child. The prejndice in favour of an open fireplace is so strongly rooted that it will be long before the bulk of the population will be persuaded to adopt a more economical arrangement for warming their dwellings. Feeling this strongly, Dr. Arnott adopted in his own house, and urged upon people generally, to try the principle of lighting the fire on the top, and of gradnally raising the coal as it burnt down. The mechauical arrangements for this were of the simplest kind. Dr. Arnott regards this plan as an economical one, as the coal in the lower part of the grate, being heated from incandesceut coal above, distils its hydrocarbon vapour through the already heated coal, and hence it is advantageonsly consumed, instead of producing smoke. Still this method is rarely adopted. Sir William Armstrong in his evidence puts the matter in a bold light. The defects of the open fireplace are recognised, the modes of remedying them are within the reach of everybody; yet certain it is that the pnblic do not generally avail themselves of the opportunity of saving fuel by their adoption. The evidence of Sir William Armstrong shonld be referred to, as showing in the most convincing manner that to heat a room by an open fire is utterly wrong in principle, "bnt the lnxury of sitting by an opeu fire" is indulged in, and it is so because it is to most Englishmen and women a luxury in which they have been educated, and which they will most unwillingly forego. The economy of "Arnott's stove" was examined into, by which it appears about 50 per cent. of coal is saved, and a good system of ventilation established by its use. An inquiry was made into the applicability of hot water or hot air arrangements for warming buildings. Although it is evident that little difficulty exists in applying many of the varieties of warming apparatns to dwelling houses, it was thought that in most cases the first cost wonld prove a barrier to the general introduction of any of the plans now in nse in conservatories, churches, and large manufactories. A experienced manufacturer states to us as follows:—"Hot air cannot be applied with economy for warming houses. The apparatus necessary is too costly, and, unless ventilating apparatus is put in at the same time the result is defective. Heating by air or by water may be applied as an auxiliary, but not to substitnte ordinary fires. These plans are used iu schools, not by reason of their ecouomy, but for safety, to protect the children from the dangers of an open fire." We have the additional evidence, however, that in Birmingham 1,800ft of piping were arranged in a manufactory for £200, and the cost of warming this extensive building did uot exceed 2s. a day. One witness drew attention to the suggestions and plan of Captain Galton, by which about one-half of the coal generally used was professedly saved. Captaiu Galton has favoured the committee with a description of his apparatus, to which we direct attention. A large amount of useful matter was collected and published by the commission appointed "to inquire into the best modes of warming and ventilating the apartments of dwelling honses and barracks," in 1856, and to this we refer those who are interested in this important question. We have, however, the striking fact, showing the immovability of the pnblic, that duriug the fifteen years which have passed since this commission begau its labours and reported thereon no economical result has been obtained.

(Signed) Henry Hussey Vivian.
George T. Clarke.
John Hartley.
Robert Hunt (chairman).

THE "WOOLWICH INFANT."

The 35-ton gun was fired again on the 23rd ult., for the last time before its removal to Shoeburyness, for the pnrpose of testing the new carriage upon which it has been mounted, and which is the one intended for actual service in the turret of Her Majesty's ship *Devastation*. This carriage is massively built np of wrought-iron plates, having one bracket

considerably longer than the other, as it is designed to put two 35-tons into each turret, and the long bracket on one gun carriage will correspond to the same one on the opposite side of the other, so as to suit the shape of the platform upon which the guns recoil. Considerable changes have been made in the "saddle" and other apparatus for effecting the "muzzle-pivoting" arrangements. It was essential that the saddle itself, upon which the entire weight of the gun depends, should be constructed in the strongest possible manner. As, however, it was found impossible to forge so large a mass in one piece, the jaws of the saddle and the trunnion blocks have been manufactured of cast steel. In the sides of the brackets, and directly underneath the trunnions of the gun, are huge wrought-iron slots for the saddle to rest on. These are removable at pleasure after the weight of the gun has been lifted off them, and smaller ones can be inserted in their places, thus lowering the axis of the trunnions. The saddle itself is raised or lowered by an hydraulic press immediately beneath its centre. Another hydraulic press is situate below the rear of the brackets, which elevates or depresses them, thus raising or lowering the breech of the gun. Hence it will be seen that the axis of the trunnions and the breech of the gun can be elevated or depressed to any required angle, while the muzzle of the gun remains in the same constant position. This is the principle of "muzzle pivoting," and through its agency we are enabled to dispense with the necessity of having large port holes. Connected with the rear rollers of the carriage are two eccentrics and an endless chain, by which the brackets when elevated in rear are thrown entirely upon the rollers, enabling the gun to be brought forward after its recoil with the greatest possible ease. The slope of the platform on board ship will be three degrees. The carriage will be fitted with Scott's compressor to both brackets, in order to check the recoil, which, it is anticipated, will not exceed six or eight feet. This is a most cleverly-contrived apparatus. A stout bar of wrought iron in the shape of a horseshoe passes through the base of the bracket and round the platform slide, and by means of a hand wheel and screw grips tightly the compressor plates beneath the platform. For these experiments the carriage was mounted upon a steeply-inclined wooden platform, with iron "ways," having a buffer of wood attached beneath which would come in contact with an enormous block of timber connecting the slides at the summit of the platform in case the gun should attain that position in its recoil. This precaution, however, turned out to be quite unnecessary, for the "Infant" in its most violent struggles did not get more than 8ft. up the inclined plane, which was at an angle of 8°. A number of persons were assembled to witness the experiments. Sir David Wood, the Commandant of the Garrison, and all the heads of departments in the Arsenal, together with many other officers holding various positions, anxiously watched the progress of affairs. The result of the firing was most satisfactory, both as regarded the behaviour of the gun and carriage. The initial velocity of the projectiles registered during the experiments was exceedingly good. With 115lb. of pebble powder (Waltham Abbey) 1,284ft. in one second was obtained, while with 120lb. of the same material the high figure of 1,322 was reached, being two feet in advance of any hitherto registered with this powder. It has now been decided that the calibre of the 35-ton gun is not to be increased over the 12in., the result of the series of experiments, which lately terminated, having been so entirely satisfactory to the committee.

TRIAL OF A STEAM LAUNCH.

The trial of No. 36 steam pinnace, which was made at Portsmouth on the 23rd ult., under the official supervision of the officers of the Steam Factory and Reserve, was attended by novel conditions, which deserve notice from the success which upon the whole was attained. The boat was, as its number implies, the 36th of its kind supplied to the ships of Her Majesty's navy, and in common with other pinnaces and cutters, as well as many launches, has been built for the Admiralty by Mr. John Samuel White, of East Cowes, upon his lifeboat principle. Her peculiarity apart from other boats of the kind consists in the arrangement of her propelling machinery, in the adapation of the outside surface condenser and a vertical boiler, both patented by Mr. Alexander Crichton, of the Cork Steam Packet Company which was illustrated in Plate 362 in The Artizan July 1st 1870. The condenser, as will be seen on referring to this drawing, is simply a copper pipe passing out from the boat on one quarter, at the garboard strake, and along the side of the keel, returning along the keel on the opposite side, and re-entering the boat on that quarter. The boiler is designed for boats fitted with condensing engines, and which, therefore, are without the acceleration of draught given by the exhausted steam being discharged into the funnel. It is of the vertical kind, and stands on a shallow square tank, which forms the hot well. The tubes are horizontal over the fire, the water circulating through them. The condensed steam is pumped into the well at a temperature of 100°, and being there subjected to the heat radiating from the furnace, is pumped back into the boilers at nearly boiling heat. It is estimated that, under these conditions, the pinnace would run for nearly 48 hours without having to "blow off" or carry a supply of fresh water, the waste of water being made good by sea water. Six runs over the measured mile, using a little blast, gave the boat a mean speed of 8·244 knots. The same number of runs made with no blast on gave a mean speed of 7·801 knots.

THE NEW STEAMSHIP "BOYNE."

The Royal Mail (West India and Brazil) Company's fleet of steamers has just been reinforced by a vessel named the *Boyne*, built by Messrs. Denny, Brothers, and engined by Messrs. Denny and Co., of Dumbarton. She was lately taken to the measured mile in Stokes Bay, under the command of Captain W. W. Herbert, and successfully passed the ordeal of an official trial. The directors of the company were represented by Captain Barlow, Mr. C. Chapman, and Mr. Marshall, and among other gentlemen present were Messrs. Luke and Steele (Admiralty surveyors), Mr. Orme Hamerton (Board of Trade surveyor), Mr. G. Pellatt (postmaster at Southampton), Captain Jellicoe, Captain Hay, Mr. Denny, Mr. Brock, Mr. R. Ritchie, Mr. J. Bower, Mr. Langdon, &c. The builders' dimensions of the *Boyne* are as under:—Length between perpendiculars, 360ft.; breadth, 40ft.; depth, 34ft.; gross tonnage, 3,318; registered tonnage, 2,256. She is propelled by compound engines of 500 H.P., nominal; diameter of cylinders, 100in. and 57in. respectively; stroke of piston, 4ft. 3in. With an average pressure of 54¼lb. of steam, and engines making 58¼ revolutions per minute, the results of four runs at the measured mile were as follows:—First run, 3 min. 45 sec., equal to 16·000 knots per hour; second, 5 min. 21 sec., or 11·215 knots; third, 3 min. 49 sec., or 15·721 knots; fourth, 5 min. 5 sec., or 11·803 knots; the Government mean speed being 13·576 knots per hour. The second and fourth runs were against wind and tide, the wind blowing from the south-east, with a force of 4. The *Boyne* had a total weight of coals, water, and stores on board of 1,330 tons, and her draught of water was 18ft. 10in. forward and 20ft. aft. The fittings and arrangements in every department are of the best character, and the main saloon is a splendid apartment, occupying the full width of the vessel, and very tastefully decorated and furnished. The builders received acceptance of their contract to build the *Boyne* on the 17th of November, 1870, and she left their yard under steam for adjusting on the 16th October. The *Boyne* is appointed to leave Southampton on the 9th inst. with the Brazil and River Plate mails.

INSTITUTION OF CIVIL ENGINEERS.

PNEUMATIC DESPATCH TUBES—THE CIRCUIT SYSTEM.

By Mr. Carl Siemens, M. Inst. C.E.

The author commenced by remarking that, soon after the introduction of the electric telegraph it was found necessary in large towns to establish branch telegraph stations, at which messages could be collected for, and to which messages could be sent from, the central station. Both telegraph wires and messengers were tried for the purpose of keeping up communication between the central and branch stations, but neither of these means was found perfectly satisfactory, as the messengers proved too slow, and re-telegraphing the messages added another chance to their being mutilated in transmission. Under these circumstances the Electrical and International Telegraph Company connected their central station in Telegraph-street and their nearest branch stations in the City by means of pneumatic tubes, through which carriers, containing messages, were forced in one direction by compressed air, and in the other by the air of the atmosphere flowing through the tubes into an exhausted receiver. This system of tubes, which was designed and carried out by Mr. Latimer Clark, M. Inst. C.E., and Mr. Varley, M. Inst. C.E., was still in existence, and had indeed been considerably extended since the telegraphs had passed into the hands of the Post-office authorities. It was worked by means of air-pumps, actuated by steam-engines placed in the basement of the central station. This system had comparatively a very limited power of despatching messages, except for short lengths, as it was necessary to wait till a carrier had completed the whole of its journey in one direction before another could be sent in the other direction, and it did not admit of intermediate stations being inserted, but every two stations must be connected by means of a separate tube. In April, 1863, the Prussian Government applied to Messrs. Siemens and Halske, of Berlin, to propose a system of pneumatic tubes for that city. After making numerous experiments, that firm proposed laying tubes, arranged in a circuit, to be traversed by a continuous current of air always kept flowing in the same direction. The peculiarities of this

system, namely, the continuous current of air and the power of putting carriers into the tubes at any point, gave it great superiority over previous systems in the amount of work it was capable of doing. The Central Telegraph station and the Exchange at Berlin were connected together, on Messrs. Siemens and Halske's system, in 1865, by means of two parallel lines of drawn wrought-iron tubing, $2\frac{1}{2}$ inches of internal diameter, one tube being used exclusively for the passage of carriers in one direction, and the other for carriers going in the opposite direction. The continuous current of air was produced by means of a steam-engine, working a double-acting air-pump, in the basement of the telegraph station. After the first line had been in use in Berlin for a year and a-half, and had proved perfectly satisfactory, the Prussian Government ordered an extension from the Telegraph Station to the Potsdamer Thor, with an intermediate station at the Brandenburger Thor, and expressed the intention of providing the whole of Berlin at a future time with a network of pneumatic tubes. The total length of the pneumatic lines laid in Berlin was 32,000ft., including the first experimental line of 5,670ft. On account of the great length of the second circuit of tubes they were made 3in. in diameter inside, and this dimension would be adhered to in future extensions. There was also a circular pneumatic system in Paris, but the continuous current of air was not used. Messrs. Siemens and Halske recommended their plan to the French Government before the Berlin line was constructed, but the French Government preferred a modified arrangement of their own. Each station on the French line was provided with large air-tight vessels, which were in communication with the water-mains of the town. By admitting water under a considerable pressure the air in the vessels could be compressed to about two-thirds of its volume, and by means of the air so compressed the carrier, or train of carriers, was driven to the next station, from whence it was again driven to a further station, by the air which had been compressed in another set of vessels, and so on from one station to another at stated times round the circuit. The author observed that the consumption of water by this system must be enormous, because, as the air was compressed to two-thirds of its ordinary volume, for every volume of air used, the expenditure of a volume and a-half of water was required. The French line was circular, in so far as it started from the central telegraph station, and passed through four stations, namely, at the Madeleine, the Grand Hotel, the Bourse, and the Post-office, and returned to the central telegraph station; so that the carriers were always sent through the tubes in the same direction. The working powers of the system were of course very limited. In London, there was another pneumatic line which should be mentioned, although not designed for the conveyance of telegrams or single letters, but of large parcels, namely, the large cast-iron tube, of a **D** section, running from Euston Station, viâ Holborn, to the General Post-office. Five or six years ago Messrs. Siemens Brothere tried to induce the Post-office authorities to adopt their system of pneumatic tubes for the conveyance of letters in London; but it was only in December, 1869, when the telegraph wires were being taken over by the Government, that they received an order to lay an experimental circuit between the central telegraph station and the General Post-office in St. Martin's-le-Grand. This line was completed and opened for traffic in February, 1870, and, after half a year's work, the great advantages of the system having shown themselves, a further length to Fleet-street, and subsequently to the West Strand office at Charing-cross was decided upon. The different stations were connected by two lines of wrought-iron tubing, having an internal diameter of 3in.; both lines were laid in the same trench, at a depth of about 12in. below the pavement, and parallel to one another. The tubes forming the circuit were of an average length of 18ft. 8in. For turning round street corners, and for rising and falling in the different buildings, pieces bent to a radius of 12ft. were used. The ends of every two consecutive tubes were brought close together, and joined by means of a cast-iron "double collar," similar to those used for joining cast-iron water pipes, but having in the centre of its length an annular projection 2in. wide, which was bored out just to fit over the ends of the tubes to make them butt true. A common lead and yarn joint was made at each end of the collar. Water-traps, communicating by means of slots with the bottom of the tubes, were placed at depressions on the line, to enable water, which might have got into the tubes through condensation or otherwise, as well as dust, or foreign matter, to be drawn off, without its being necessary to take up any of the tubes. A current of air was kept constantly circulating through the tubes, by means of a steam-engine and double-acting air-pump, supplied by Messrs. Eastons, Amos, and Anderson, placed in the basement of the central telegraph station. Each station on the circuit had two sending and receiving instruments, one on the up and the other on the down line of tubes. The instruments consisted of two short tubes, fixed side by side in a rocking frame, each of which could be brought into line with the circuit of tubes at the pleasure of the attendant. Each end of the rocking frame was faced and worked against the faced side of a boss, into the centre of which was fixed a piece of wrought-iron tube, forming part of the circuit. Three annular grooves were turned in the faced side of the boss round the tube forming the end of the circuit. The use of these grooves was to prevent the escape of air between the ends of the rocking frame and the bosses at either side of the apparatus. One of the tubes in the rocking frame, that called the sending or "through" tybe, was simply a hollow cylinder, of the same internal diameter as the tubes forming the circuit. When this tube was in line with the main tubes a carrier could pass through the instrument without being stopped, and this tube was used when it was desired to put carriers into the circuit. The other, or receiving tube, had a perforated diaphragm at its "down-stream" end, so as to arrest the carriers when it was placed in line with the main tubes of the circuit. This tube was **D** shaped in section, with a flat cover, which could be taken off if required, as, for instance, to remove carriers should two arrive at once, and so prevent the rocking frame being moved. The flat cover of the receiving tube was furnished with a pane of glass, to enable the attendant to see when a carrier had arrived. To prevent the continuous flow of air in the whole system of tubes from being impeded, should the receiving tube be left in a circuit after it had caught a carrier, there was a by-pass, which communicated with the tubes of the circuit on both sides of the instrument. A sliding rod, held on suitable supports, was supplied for pushing the carriers out of the receiving tube when intercepted and brought out of the circuit. The manipulation for sending and receiving carriers was extremely simple, and a treadle was provided to enable the attendant to move the rocking frame with his foot. The carriers for the reception of telegrams, letters, &c., consisted of small cylinders made of gutta percha, papier maché, or tin, covered with felt, drugget, or leather. It was found, in practice, that the carriers need not fit the tubes at all accurately. Mr. Culley, M. Inst. C.E., chief engineer of the post-office telegraphs, had adopted the block system, such as was used on railways, for working the tubes, and he employed instruments introduced by Mr. Tyer, Assoc. Inst. C.E., for making the signals. The use of the block system prevented the tubes being able to develop their full working powers, which would be obtained by sending carriers one after another at half-minute or shorter intervals—a mode of working that could be easily carried out with a constant current of air, as was the case when the circular system was worked independently of other systems, which was not yet the practice in the metropolis. The total length of line now working in London, from Telegraph-street to the West Strand office and back, was 6,890 yards, as follows:—From the instrument room, on the third floor of the central telegraph station to the General Post-office, 852 yards; from the General Post-office to the Fleet-street office, 1,206 yards; and from the Fleet-street office to the West Strand office, near Charing-cross, 1,387 yards.

The following results as to speed were obtained during experiments made with the two sections first opened. The mean pressure during those experiments was 7lbs. per square inch at one end of the circuit, and the vacuum at the other end of the circuit was 11in. of mercury under these conditions, the circuit being worked with both pressure and vacuum, the times were:—

	YARDS.	M.	S.
Telegraph-street to General Post-office	852	1	54
General Post-office to Temple-bar	1,206	2	28
Temple-bar to General Post-office	1,206	2	10
General Post-office to Telegraph-street	852	1	13
Totals	4,116	7	45

These experiments proved that the speed of the carrier was much greater as it approached the vacuum end of the tube than it was at the other end.

The necessity of having a steam-engine with air-pumps and reservoirs was a great hindrance to the general introduction of pneumatic tubes; but this inconvenience had been successfully removed by the construction of an exhausting apparatus, working by the direct action of steam upon a current of air. In this exhausting apparatus the steam from a boiler was made to issue, in the form of a hollow cylinder, from an annular nozzle placed in the centre of the apparatus, the opening having a width of about one millimetre all round. The steam issuing in this form had the greatest possible surface, both inside and out, for contact with the air in the apparatus, which air was in connection with, and was drawn from, the pneumatic tubes. With one of these exhausters a vacuum equal to a column of 23in. of mercury was obtained, with a less expenditure of steam than would be required to work a steam-engine and pump to effect the same object. The principal recommendation of the steam exhauster, besides its extreme simplicity and the small space it occupied, was its cheapness of construction, as the cost only amounted to about one-twentieth part of an engine and pumps. Where so large a traffic was not expected as in London, the tubes, instead of being laid side by side in the same trench, could, at a trifling additional cost, be laid in a large circuit, and so be made to include many more intermediate

stations, each station in that case having only one sending and receiving instrument.

Experiments made at Berlin proved that, in very long lines of tubes of small diameter, a sufficient velocity of the column of air could be obtained with the pressure at the two ends differing within quite practical limits. If the carrier was made so as to move with very little friction, its speed would be nearly equal to that of the air by itself. The momentum of the carrier and that of the column of air might be entirely disregarded, as both were infinitely small when compared with the prevailing friction of the air in the tube. As under equal conditions of pressure at the two ends the speed in the tube increased as the square root of the diameter, and decreased as the square root of the length of the tube, the length of a pneumatic system might be extended with similar results as to speed, in the same proportion as the diameter of the tubes could be increased; that was, the same speed as was obtained through a tube of a certain diameter and length, might be obtained through another of double the length and double the diameter, the difference of the pressure at the two ends of the tubes remaining identical.

Up to the present time, as far as the public was concerned, the pneumatic tubes in London, Berlin, and Paris had only been used for the conveyance of telegraphic messages, but the British Post-office authorities had already considered the question, whether it would not be advantageous to have the letter-post service in London executed by means of pneumatic tubes. With such a system of distribution an accumulation of letters at principal offices would be entirely avoided.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.

INTRODUCTORY ADDRESS.

By Mr. David Rowan, President.

We now begin the business of the fifteenth session of this Institution, with every prospect of continued usefulness and prosperity. In accordance with the resolution of the special meeting of the members held on the 25th January, 1870, the Institution was, after having obtained the license of the Board of Trade for that purpose, registered as an incorporation on the 24th July last; and the Institution now possesses all the advantages appertaining to a corporation. The present is the first stated general meeting of the Institution in its corporate capacity, and is held in the terms of the Act of Parliament. The membership consists of all who were members of the old Institution at the date of incorporation. The present president and council are those appointed at the meeting of the Institution in April last, and they continue in office for the same period as they would have held office if the Institution had not been incorporated. Mr. Smith having resigned the secretaryship of the Institution, the council, after very mature consideration, and with the hope that arrangements may be made by which the situation of the secretary shall be improved, and the success of the Institution promoted, have elected Mr. Millar, who was Mr. Smith's assistant, to be secretary.

During the past session several papers of great practical importance were read, and followed by discussions. Several of these papers were suggestive, and I may here state that this address is confined to the consideration of two of the subjects suggested and treated of in the papers.

Mr. Henderson's paper "On Conical Surface Condensers" suggests an inquiry of practical importance, namely, the effect of the use of surface condensers on the duration of marine boilers, which has not yet been discussed by this Institution.

When the surface condenser was introduced by Mr. Hall, the boiler was filled with fresh water, and the waste was made up by distillation from a supplementary boiler. Under this treatment the boiler was found to suffer rapid decay on the internal surface, especially in the region where the feed water was introduced. An action was induced by the brass and copper of the condenser tubes, the air pump, bucket valve seats, guards, and the feed pipes forming one of the plates of a galvanic battery, the unprotected iron of the boiler forming the other plate, the feed water being the conductor. By this treatment the destructive effect on the boiler was so great as to cause the entire disuse of the surface condenser for many years. The use of high steam pressure has again brought the surface condenser into general practice, but the treatment of the boiler is different. The practice now is to fill the boiler with salt water, which is occasionally blown off, and this, along with the waste from safety valves, leakages, &c., is made up by salt water. A scale is by this means allowed to form, covering the whole internal surface of all parts of the boiler below the water line, which in great measure protects it from injurious action, the water being prevented from touching the boiler by this coating of the deposited salts from the sea water. While protecting the boiler, however, from one evil, this mode of treatment introduces another of scarce less prejudicial effect, for by coating the whole internal surface with scale, a layer of non-conducting material is interposed between the heat and the water, thereby wasting fuel and maintaining the plates which are exposed to the fire at a much higher temperature than they would be were the boiler quite clean. So far as I am aware this is the general treatment of marine boilers used with surface condensers, and carrying steam of sixty to eighty pounds pressure. Under such treatment the duration of the boiler may be taken at from five to six years, and even less in some instances which have been reported. It is not unusual that in protecting the boiler the feed pipes are attacked and suffer rapid decay. In the case of land engines the boilers remain in good condition, if carefully kept, for a period of twenty years, and there does not appear any good reason why marine boilers should not at least approach that age. The difference between land and marine boilers consists principally in this, that in the former all the parts which I have enumerated as being made of brass or copper are in the latter entirely of cast-iron, when no action of the kind to which I have referred is induced. We have found a precisely similar action taking place in kitchen boilers used for supplying houses with hot water, when using a boiler and circulating pipes of iron—the cistern near the top of the house being of wood lined with lead—the use of the two metals, lead and iron, when used with our pure Loch Katrine water, which leaves no deposit to protect the boiler, is sufficient to cause its destruction in a short time. Another illustration of the same kind is to be found in tubular boilers used in Glasgow with Loch Katrine water—the feed water being conveyed from the street mains to the boiler through lead pipes. I put in a new boiler in July of this year; during the first two weeks the water in the gauge glass became discoloured as if with rust—the feed water was conveyed through a long series of lead pipes. I then caused the water to be passed through a cistern containing zinc, and in the course of a very few days the water in the gauge glass became quite pure and colourless. In the case of a boiler that was repaired and retubed—the feed water being conveyed through lead pipes—in nine months working the tubes were entirely destroyed, but only on the upper surface, where they required to be renewed. From the experience of some practical engineers it would appear that with the ordinary treatment of boilers now in use this action, so prejudicial to their duration, may be arrested by a proper distribution and use of zinc, interposed in the course of the feed water and within the boiler. A rapid destruction of the zinc ensues, but the boiler is protected. From information furnished to us by Mr. Wallace, of Liverpool, superintending engineer to the Messrs. Allan, engines which ordinarily indicate 1,800 H.P., require for the protection of the boilers upwards of 2,000lbs. weight of zinc in four months, or about the rate of 1lb. of zinc per 100 H.P. for 24 hours; by such means the boilers have lasted for nine years; but this, I understand was with pressures of 20 to 25lbs., and not 60lbs., as at present in use. Great diversity of opinion and consequently of practice prevails on this subject, some affirming that boilers with surface condensers cannot be maintained for any length of time in good order without the use of salt water, and allowing them to be partially filled up and blown off periodically. Others maintain that no salt water should be allowed; they give their experience of several boilers which have been in use for eleven years, carrying steam of 120lbs. pressure, which are still working, and where no salt water could be introduced. Should this experience be correctly recorded, and so far as I know there is no reason for doubt on the subject, then the coating by scale or salt of the inside of the boiler, so destructive to its duration, and so wasteful of fuel, may be avoided by adopting the method originally introduced by Mr. Hall, namely, to discard entirely the use of salt water, and make up in excess the waste by distillation, so as to admit of the water being changed by partial blowing off. Were these precautionary means adopted and proper care exercised, there seems no valid reason why steam boilers should not last as long at sea as on land, making some allowance for rougher usage in the one case than the other, and when both sets of boilers are under similar circumstances as to pressure.

In many respects the most important paper read during the last session was that by Professor Young, "On the Education of the Mining Engineer." The principal feature of the paper was a suggestion to regulate admission into the profession by the result of an examination of each candidate by a board composed of practitioners. A very complete definition of what the attainment of the mining engineer should be, carried to the limits of theory, besides giving very cogent illustrations and reasons why he should be a thoroughly trained and skilful person Mining is an essentially important and very hazardous calling. In the United Kingdom there is probably thirty millions of money invested in collieries alone; add to these the amount invested in mines of iron, copper, lead, and tin, the result will be a probable capital of sixty millions of money committed to the charge of engineers or managers. In all our mines there are probably not less than four hundred thousand workers, and these are all more or less exposed to special dangers. In

the collieries alone there are about a thousand persons killed annually, and probably five times that number injured. The number of accidents at any mine very much depends on the management, hence the necessity of having careful and skilful persons entrusted with that duty. The obligation of carefulness ought to extend from the mining engineer to the humblest workman who may be employed underground. Many lives are lost by explosions, the causes of which can often be traced to some reckless or ignorant workman, who has removed the top from his lamp, or more frequently, as the lamp is often locked, by canting it over partially on its side, applying his pipe, and sucking the flame through, which can easily be done. On the other hand, it often appears that ordinary precautions have not been adopted, or that rules, good in themselves, have been suffered to fall into disuse. Properly qualified and duly certified engineers should possess education and practical experience, sufficient not only to lay down useful rules and point out necessary precautions, but authority and influence to enforce their observance. There is, therefore, strong and well-marked specialties about the functions of the mining engineer, which should require him, above all others who bear that title, to be a man of proved professional attainments. Mining is the basis on which rests the great superstructure of our national industry, and whatever tends to promote the interest of this vast underground occupation is a matter of national concern. For the profession of mine manager in England a regular apprenticeship is gone through; men having the superintendence of collieries have youths articled to them, who for several years are under their tuition: The apprentice sees the various appliances that are used to meet the emergencies that occur from day to day, going down the pit regularly, and thus gradually increasing in fitness for his duties; in this way a practical training is obtained, and at the end receives a certificate of merit, should he be deserving. In Scotland this has never been done. In this training of managers much is suggested that would also be valuable to the mining engineer. While the utmost attainable scientific knowledge is desirable, a practical acquaintance with the details of mining is necessary to the full equipment of the mining engineer. With all the advantages of superior training, however, whether from larger accumulation of explosive gases, greater extent of working, or other causes not easily explained, it is notorious that almost all the great colliery accidents take place in England, few, if any, occur in Scotland. In the year 1870 there were 3,142 collieries in Great Britain, with 282,473 men and boys employed in them; there were 112,875,725 tons of coal raised; 991 lives were lost by accident, or 113,900 tons of coal raised per life lost. In comparing the lives lost and the quantity of coal raised in the English collieries with that in Scotland, the result is greatly in favour of Scotland, there being one life lost in the English collieries for every 106,806 tons of coal raised, while in the Scottish collieries one life is lost for every 201,818 tons of coal raised, being a ratio of nearly two to one in favour of Scotland.

We have in the maritime affairs of this country an instance in point. An examinational test of the technical knowledge and practical skill of him who would command a ship is required. The sailor must pass the examination of a constituted authority before he can go a voyage as second mate, a further examination before he can advance to the post of mate, and a third trial of his attainments before he can command a ship. The stringency of rule which requires those in command of ocean-going vessels to undergo the ordeal of a professional examination before a competent tribunal, ere a certificate of competency can be procured, obviously arises from the consideration that valuable lives and much property is entrusted to the care of those in charge. The same reasons which justify and require an examinational test of the intending shipmaster apply with equal force to the mining engineer and to the mine manager also, life and property being in either case at stake. Although navigation rests on mathematical and physical astronomy, yet the Board of Trade, in requiring that every shipmaster and mate should possess a competent knowledge of and skill in that great art, does not demand of those who would command a ship a knowledge of the properties of the sphere, of the science of nautical astronomy, of chronometry, of magnetism, or of meteorology, all of which relate intimately to the navigator's art, and of which that art rightly understood is the technology, or the application. So of the mine manager, a qualified intelligence and practical experience should suffice for the proper discharge of his functions, without aiming to enact more than is absolutely wanted, and which we know will not in one instance out of many be supplied. For the mining engineer a higher range of intellectual attainments is needed, but here also it might be well to assign a large place to a practical acquaintanceship with the details of mining, even at the expense of so much of pure science, as is indicated in the curriculum. In like manner the sea-going engineer requires to pass a similar examination, and acquires a second or first-class certificate, according to his knowledge or skill in the management of the steam-engine. Up to the present time I am not aware that the examination of sea-going engineers has done much good; it is conducted by an appointed examiner, who puts a few stereotyped questions, and, upon the answer to these, grants a certificate. The preparation for such an examination consists in the person desiring a certificate leaving his vessel for a few weeks, placing himself under the teaching of one, and there are many, who profess to prepare him for such an ordeal, and knowing well the nature of the questions that will be proposed, gets posted up on these until his examination is over, and then the whole is forgotten.

Many of our young mechanical engineers begin their apprenticeship with the desire to go to sea. Were it a condition that a certificate of attendance for a definite time at the classes of some acknowledged institution or teacher was required, and when a practical acquaintanceship with the management of the steam engine had been obtained, that the applicant must then submit to undergo an examination conducted by a properly constituted board of examiners, such conditions standing in the way of his advancement would induce to a preparation in early life, without waiting until mature years, when obliged by circumstances to undergo that, which by many is looked upon as an infliction to be submitted to, a thing to be avoided rather than desired.

As an inducement to a higher education, I presume we all agree with Professor Young on the propriety of testing, by examination, the qualifications of the intending mining engineer, as also the mine manager. He has, doubtless, placed before us the full breadth of the intellectual demand for this profession. There may be some difficulty about the constitution and composition of a board of examiners. Were this difficulty overcome, the action of such a board would not be limited to mining engineers, but with the progress of technological studies in other fields of engineering, it would require to go further. The same reasons which apply to the mining engineer, and all those in charge of mines, apply with equal force to every other branch of this great profession. All engineering worthy of the name is applied science, and the intimate connection that exists between the various branches of the profession, binds him who would establish an educational test of entrance into any one of them, to extend a similar obligation to all entrants into each recognised branch of the same. Such would consummate the technological teaching of our schools and universities, giving it an aim and purpose which would animate and excite the diligence of the student. Civil engineering is the technology of mathematical conjoined to physical science, and is the parent stem of applied physics, which gives off many branches, and includes machine construction, shipbuilding, architecture, military engineering in many of its features—the engineering of roads, mines, railways, canals, docks, bridges, waterworks, gasworks, &c., each of these departments requiring its specialties of knowledge and of skill. To raise all the leading sections of engineering to the rank of professions by diploma, if such a plan could be systematically carried out, would react beneficially on the school and university education of the country, and through these on all our industrial occupations. While cherishing, however, the hope of obtaining much better professional and artisan classes for education in the field of industry, under the stimulus of appropriate institutions, and of distinction bestowed upon superior attainments, I cannot disguise from myself the inherent difficulties. It may not be easy to raise the intelligence of the people, or any considerable portion of them, above a certain level, by any known method of instruction. Much time is required ere the human mind can be instructed and educated, as the people are constrained to work in order to procure the means of subsistence. This alone forms one of the limiting boundaries of intellectual improvement. This boundary is more remote in some countries than in others, but it must exist somewhere. It would seem, therefore, to be quite as difficult to imagine a state in which all the citizens shall be highly educated as a state in which they shall all be wealthy. These two positions may be looked upon as correlative. There is probably no country at the present time that can hope to carry so large a portion of its people to so high a degree of culture as Great Britain. This I state on the supposition that national education, by recent or prospective enactments, will be adapted to our national requirements. In Scotland the average attendance of children at school reaches a higher proportionate number of the whole than in any country in Europe or America; and with good schools, more of them, and lower fees, this proportion will become still higher.

Our hope for the engineering arts rests upon obtaining good elementary schools, which would prepare the ground for the introduction, at an early age, of technology or applied science. As a branch of general education this study should be carried on to some extent along with the practice of the workshop, and conducted at hours when those who have to subsist by their daily labour can attend. It need not be thought strange for a common school to carry on the work of technical instruction. Already it is in full activity in some of the humblest schools in the land. It is well known that arithmetic, or the science of numbers, can be taught as pure science, just as geometry or algebra may. Yet every book on arithmetic contains hundreds of questions to be solved

relating to trade or bnsiuess, wherein the science finds application. The arithmetical class book is a book of arithmetical technology. Essentially similar books for instruction in physics and chemistry should be found in the list. Neither of these two branches, however, can be taught, even in the most elementary form, without the aid of experiment, and with the introduction of these studies additional and different appliances are needed for the teacher. The process of education required for the engineering arts would seem to be, first, the elementary school. Between this and the practice of any art should be fonnd the technological class for the teaching of science, and its application to particular arts or professions. No amonnt of science teaching can supersede the need of apprenticeships for any destined occupation. Technical instruction does not imply the practice of an art, nor even the learning of an art; it is an education in principles which leaves the youth free to exercise his mind in the application of those principles as opportunity may offer or demand. The refinements of science indispose the mind for physical labour; it loves retirement, and dislikes the violent and robust life of daily toil. Neither can I disguise from myself its sensational effects—its pnrsuit in the discovery of new relationships, combinations, and facts—that which is novel and interesting to-day becomes known and is a thing of the past tomorrow, leaving the mind free in the pursnit of discovery. Essentially different is the condition of mind of one who practices an art. Here it is necessary to eliminate as mnch of novelty as is possible; to be contented to repeat from day to day the same processes; to reduce all details in business as mnch as possible to a system, guided in doing so largely by practical experience. Practical engineers must be raised from the toil of manual labour. Men of science are of limited nse in the workshop. It is when a knowledge of theory is conjoined with practice that the greatest good is achieved. This I believe to be in harmony with the industrial history of our country, and is likely to be so in the futnre. The tendency of scientific research is to withdraw the mind from the practical, while the restrictions imposed on the practitioners of an art is to be careful of novelties. So it is a rare phenomenon to find in the same person a master in science and a successful practitioner. Technical education, however, does not presume to individual research in abstract science, but is instruction in the scientific principles of any art or profession in the practice of which it is to find application. Mnch attention is at present being devoted to this snbject. In all our great centres of industry institutions are being opened and classes formed for the teaching of applied science. The Institntion of Mining and Mechanical Engineers in Newcastle have been instrumental in opening an institution, the particulars of which I have received from E. F. Boyd, Esq., the president. As to Edinburgh and Manchester, similar institutions already exist, and in onr own city the Andersonian University and the Mechanics' Institntion are making the necessary arrangements.

It is now over fifty years since mechanics' institutions were established; these have not been successfnlly supported, and I am not aware of one that has realised the expectations of its founders, or served the purpose for which it was established. The instruction given by evening lectures is of the most desultory character. Experiments are condncted more to please the fancy than to instruct the mind. No previous preparation being required, the efficiency is limited. This must be departed from, in so far as the preparation at the elementary school should be brought up to a requisite standard. Instrnction is to be given in science, with its direct application to the arts and business of life, the whole consummated by examinational test before a competent board of examiners, and a diploma or pnblic badge of distinction bestowed upon the deserving. Mechanics' institutions failed in attracting any considerable portion of the very class for which they were established, namely, the artisan class. The great majority of those attending being young men employed in warehouses and public offices, in whose calling the teaching of science could find no appropriate application. The means to be adopted for inducing attendance at either the elementary school or the more advanced technological class has not received so mnch consideration as the establishing of snch schools and classes. The attendance at the elementary school is a qnestion of great national concern; that at the technological class mnst be left to individual effort and emulation.

When the social condition of the inhabitants of our city is considered, measured by the value or rental of the occnpied houses, the urgency of the questions awaiting legislative enactment for edncation appears in strong light. In the city proper of Glasgow there are more houses at and nnder £3 rental than there are at £5; altogether there are at and under £5 rental 35,054 houses, above £5 and under £10 there are 39,116 honses, and altogether above £10 there are 19,822. Allowing approximately 4, 5, and 7 inhabitants for each of those houses, there are living in houses—

At and under £5 rental	....	140,216	474,550
At and under £10 „	....	195,580	
Above £10 „	....	138,754	

Looking at these figures, by what other method than by a compulsory and free system of education are the yonths living in these low-rented houses to be reached. I carefully guard against associating in any way whatever the idea of immorality or crime with low-rented houses, for in those very honses are to be found fine illnstrations of virtuous and good living people, but who are absolutely without the meaus of educating their children.

In reference to the inducements for those who ought to attend the more advanced classes, who have the means at their disposal, which implies time and opportunity, what does the history of the past reveal? More than thirty years ago our university, in advance of the times, and foreseeing the need of technical iustrnction, instituted a chair of civil engineering. It has only been by the system of previous preparation introduced, and the great repntation of the distinguished Professor, Dr. Rankine, that after the lapse of so many years this class has been brought up to the number of fifty stndents, and this out of our city with its five hundred and fifty thonsand inhabitants, besides the whole west of Scotland, where a majority of the people are engaged in the industrial arts.

When this engineering diploma shall be considered an honourable distinction, and the want of it a barrier in tho path of professional progtess, then may we hope to see technological classes increase in numbers, and in place of one professor instrncting in many branches there shall be many assistants to each department, and we shall have a class of men instructed and educated in their own profession, elevated by such intelligence in the scale of being, and raising by their influence all those by whom they are surrounded.

THE MANCHESTER STEAM USERS' ASSOCIATION.

CHIEF ENGINEER'S MONTHLY REPORT.

The last ordinary monthly meeting of the execntive committee of this Association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, October 31st, 1871, Sir William Fairbairn, Bart., C.E., F.R.S., LL.D., &c., President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—During the past month 272 visits of inspection were made, and 573 boilers examined, 437 externally, 8 internally, 1 in the flue, and 127 entirely, while in addition 5 boilers were tested by hydraulic pressure. One of these hydraulic tests was made simply to ascertain the sufficiency of a boiler already in work, while in the other 4 cases the boilers were new ones, and were tested by hydraulic pressure, as well as specially examined, both as regards their construction and complement of fittings, before leaving the maker's yard. In the 573 boilers examined, 96 defects were discovered, 6 of them being dangerous. Furnaces out of shape, 1; fractures, 17—2 dangerons; blistered plates, 3; internal corrosion, 14; external ditto, 17—3 dangerous; internal grooving, 10; feed apparatus out of order, 1; water ganges ditto, 5; blow-out apparatus ditto, 1; fusible plugs ditto, 1; safety-valves ditto, 3; pressure ganges ditto, 12; boilers without feed back pressure valves, 10; cases of deficiency of water, 1; dangerous.

Explosions.

On the present occasion I have four explosions to report by which three persons were injured, but fortunately no one killed. In three cases the scene of the catastrophe has been visited by officers of the Association, and particnlars taken. Not one of these explosions sprung from boilers nnder the charge of this Association.

"Tabular Statement of Explosions from September 22nd, 1871, to October 27th, 1871, inclusive.

Progressive No. for 1871.	Date.	General Description of Boile	Persons Killed.	Persons Injured.	Total.
32	Sept. 22	Portable Vertcl.: Crane Boiler Internally-fired	0	2	2
33	Sept. 26	Double-flued, or 'Lancashire' Internally-fired	0	1	1
34	Oct. 9	Portable Multitubular locomotive type Internally-fired	0	0	0
35	Oct. 25	Camber-ended Externally-fired	0	0	0
		Total	0	3	3

An Explosion due to the Safety-valve being stuck fast by Corrosion.

No. 32 Explosion, by which two persons were injured, occurred at about half-past twelve o'clock on the afternoon of Friday, September 22nd, at a public dock at one of our large seaports. The boiler, which was employed for working a crane, was a portable one, and of the internally-fired vertical cylindrical type, the flames passing to the chimney through a central tube connecting the crown of the shell with the crown of the firebox. In the construction of the firebox, however, there was a little peculiarity, the sides, instead of being cylindrical, being corrugated or fluted vertically, so as to form ten cells, the object it is presumed which the patentee had in view in adopting this arrangement being to increase the heating surface. The shell of the boiler was 7ft. high by 3ft. in diameter, and the firebox 4ft. 8in. high by 2ft. 6in. in diameter; the thickness of the plates being five-sixteenths of an inch in the shell, and a quarter of an inch in the firebox, while the ordinary working pressure was about 40lb. on the square inch. The boiler gave way at the bottom of the firebox, the plate rending in a circumferential direction for a length of 2ft. 8in. in the neighbourhood of the ring seam of rivets at the Z iron forming the bottom of the water space between the firebox and the shell. In consequence of this rent, the bottom of the firebox, losing its attachment to the ring of Z iron, was bulged inwards, and thus an opening made through which the steam and water rushed out in a downward direction while the boiler was shot upward just like a sky rocket, and thrown into a lighter moored a short distance from the quay; added to which two persons were injured, one of them being blown off the quay into the water by the force of the explosion. On examination of the boiler after the explosion it was found that the plate where the rupture had occurred was wasted by external corrosion, some of the rivet heads being completely eaten away, and the plate reduced to three-sixteenths of an inch in thickness for a width of some three or four inches throughout the whole extent of the rent just described above. This wasting of the plates, though clearly a source of weakness, does not appear however to have been the sole cause of the explosion. The safety-valve also was found to be in a most unsatisfactory condition. The valve was of lever construction loaded by a spring balance, the lever passing through an eye as a guide. Exposure to the weather had rusted the lever and the guide where in contact with one another, until they became locked fast, while the joint of the swivel piece, bearing on the safety-valve, was similarly affected. It appears, therefore, that the safety-valve was quite inoperative, and this being the case, as the engine was standing at the time of the explosion with the fire banked in the furnace, there seems no reason to doubt that the boiler burst simply from accumulated pressure through the defective condition of the safety-valve. To this it may be added that the pressure gauge had been removed to prevent its being stolen, so that no warning would be given of the impending danger. Had there been a good pressure gauge it would have acted as a telltale on the defective safety-valve. The corrosion discovered at the bottom of the firebox of this boiler shows the importance of occasionally lifting these small vertical boilers from their seats, or at all events removing the firebars, or anything else that may impede examination, in order that the ring of rivets at the bottom of the water space may be fully examined. It would appear that these seams of rivets are subjected to a more severe strain than is generally supposed, and therefore this is a point worthy of greater attention than it has hitherto received. In conclusion, attention may once more be called to the importance of equipping such boilers with safety-valves of the external pendulous dead weight class, which are not liable to such derangements as the one from which this explosion sprung; while it must be clear that competent inspection would have detected the derangement in question, as well as the corroded state of the firebox.

An Explosion due to Wasting of the Plates by External Corrosion.

No. 33 Explosion, by which one person was injured, occurred at a small weaving shed, at about one o'clock on the afternoon of Tuesday, September 26th. The boiler was of the ordinary "Lancashire" type, having two furnace tubes running through it from end to end. Its length was 20ft., its diameter in the shell 7ft., and in the furnace tubes 2ft. 2in.; the thickness of the plates in both cases being three-eights of an inch, and the working pressure 60lb. The boiler gave way in the outer shell, rending in the first instance longitudinally at or about the line of seating blocks on the left hand side. This primary rent, after extending across the last ring of plates but one, assumed a circumferential direction, and, running round the boiler in an irregular spiral course, reduced the greater portion of the shell to fragments. On the occurrence of this rent the boiler was moved forwards some five or six yards, and turned bottom upwards, while the boiler house and boiler setting were completely destroyed, and the proprietor of the shed, who was in the adjoining engine house, seriously bruised and scalded. On turning to the cause of the explosion, it may be pointed out that the position in which this boiler was set was not a happy one. It was seriously exposed to the action of damp from the following circumstances:—The boiler was set at the bottom of a hill side, the space in which it stood having been cut out of the earthwork, and finished off with a retaining wall, against which the hill abutted. The brickwork seating of the boiler was set directly against this retaining wall, so that the wall had the damp earth on one side of it, and one of the boiler flues on the other. In consequence of this, moisture from the hill oozed through the retaining wall into the flue; and as the boiler was only used occasionally when the supply of water for the turbine ran short, the damp in the seating for the greater portion of the year had an undisturbed opportunity of corroding the plates, and thus, though the boiler had only been laid down about two and a half years, it was so seriously wasted that the plates, three-eighths of an inch thick originally, were so reduced at the line of the primary londitudinal rent that they had become as thin as a sheet of paper, so that the boiler burst simply from loss of metal. It should also be pointed out that though the boiler was set on side walls, which is a good arrangement, yet that the side flues appear to have been so cramped as to have been inaccessible for purposes of examination, while it is very possible that the soot had choked up the lower part of these flues, and that this, combined with the drainage from the hill, had tended to promote corrosion. This is by no means the first explosion that has been met with from drainage finding its way into the seatings. It shows the importance of having all the external brickwork flues of boilers accessible to examination; while it must be clear that competent inspection would have detected the dangers to which this boiler was liable, and prevented the explosion.

An Explosion due to Working a Boiler without a Safety-valve.

No. 34 Explosion, by which fortunately no one was either killed or injured, occurred at a weaving shed at about half-past six o'clock on the morning of Monday, October 9th. Owing to the press of other engagements an officer from this Association could not be despatched to investigate the cause of this explosion immediately upon its occurrence, and on an inspector's visiting the scene of the catastrophe several days afterwards, he found that the boiler had been removed, and that no information could be gained concerning it. I have, however, been kindly supplied with particulars by an engineer who was able to make an examination at the time, which, though brief, show that this explosion is by no means devoid of interest. It appears that the boiler in question, which was one of the portable multitubular locomotive type, and measured about 8ft. in length by 2ft. 6in. in diameter in the cylindrical portion of the shell, was temporarily connected, along with another boiler of a very similar description, to a "Lancashire" mill boiler. The "Lancashire" boiler had a safety-valve, but neither of the smaller boilers had any, while the pipes connecting the small boilers with the larger one were each fitted with a stop cock for cutting off the communication, and thus robbing them of the use of the safety-valve on the other boiler. On getting up steam on the morning of the Monday on which the explosion occurred, the attendant forgot to open the stop cock on the steam pipe, so that the pressure in the boiler was bottled up, in consequence of which the front end plate of the firebox was blown out to a distance of twenty yards and the boiler shot back. It may be added that the connecting steam pipes are stated to have been so small that when the boilers were urged the steam frequently indicated 80 lb., through the safety-valve on the main boiler was set to blow at 60 lb. It is further worthy of note, that it was found on examination that between thirty and forty rivets in the outer casing of the firebox were mere dummies, put in to fill up holes mis-punched. These dummy rivets gave the appearance externally of being so many stays. Thus it will be seen that the boiler had altogether been turned out in a most bungling manner.

INSTITUTE OF MECHANICAL ENGINEERS.

MILLER'S CAST-IRON BOILERS.

By John Laybourne, Esq.

The following is an abstract of the paper on the above subject:—

This boiler is composed of a series of cast-iron sections, of two patterns only, each of comparatively small size, so as to contain only a small quantity of water; those at the front end form a succession of arched tubes over the firegrate; and the rear sections consist each of five vertical tubes, united by a transverse horizontal tube at top and bottom, and placed with the tubes in each section opposite the spaces in the next. The whole of the sections of both patterns are bolted together by flanged joints at the bottom, each section having a communication through the bottom joints with the adjoining sections on either side; and

a smaller wrought-iron pipe from the top of each section conveys the steam to a main steam-pipe, common to the whole boiler. All the joints are protected from the action of the fire, those at the bottom being below the fire level, while the joints at the top are in a chamber above the top of the flue. For the purpose of insuring efficient circulation of the water in all portions of the boiler, the arched sections at the fire end are cast with a longitudinal mid-feather in each leg, by which the ascending current of heated water on the inner side exposed to the fire is separated from the descending current of cooler water on the outer side; and in the rear sections the vertical tubes have an internal circulating tube placed within each, the heated water ascending through the outer annular space, and the cooler water descending within the circulating tube. All the sections of the boiler are left free to expand with the heat, the rear sections being attached together by only a single central joint, and the wrought-iron steam-pipes at the top are long enough to allow of yielding to the requisite extent; the arched firebox sections are attached to the rest of the boiler on one side only, and are free to expand on the other side. No case has occurred of explosion with any of these boilers; and in the very few instances in which accidental fracture of the cast-iron has taken place, the only result has been that the water contained in the boiler has flowed out through the crack, without causing any damage beyond putting the fire out. By means of the flanged joints, a broken section in any part of the boiler can be readily removed, and replaced by a new one, without disturbing the rest of the sections, which are all duplicates of one another. Specimens were exhibited of fractured pieces taken from the boilers, illustrating the harmless nature of the cracks occurring in the cast-iron, and showing also that the quality of the metal remained unimpaired after more than two years' working. The boilers are kept clean by blowing off at regular intervals, according to the quality of the feed water, and any deposit accumulating in the bottom portions is raked out whenever necessary, by taking off the bottom covers at the ends of the boiler. As the total quantity of water contained in the boiler is small, in proportion to the extent of heating surface, the water level is in some cases maintained at the required height by means of a self-acting feed apparatus, consisting of a hollow ball suspended from the arm of a lever controlling the feed cock; two pipes extending some distance horizontally communicate respectively with the top and bottom of the ball, the former terminating at the high water level inside the boiler, and the latter at a lower level. As soon as the water level rises and covers the orifice of the upper pipe, the steam previously contained in the ball becomes condensed, and a vacuum is formed; and the ball then becoming filled with water entering from the boiler, depresses the lever, and shuts off the feed. When the water-level falls again below the orifice of the upper pipe, the water runs back out of the ball into the boiler, and a counterpoise upon the lever raises the ball and turns the feed on again. One of these cast-iron boilers has now been at work for two years and a half at the writer's works with complete success, and with an important economy in fuel. Several other boilers of the same construction are also in use at other works, and have proved entirely satisfactory. The particulars were given of a series of experiments made to test the evaporative power and economy of the boiler at the writer's works, and the average duty amounted to nearly 11lb. of water evaporated from 100 deg. temperature of feed per pound of Ebbw Vale coal.

H.M.S. "GLATTON."

The first trial of this peculiar vessel took place on the 7th ult. off Sheerness. The trial was chiefly to prove whether her guns could be worked with facility and safety; although the working of the engines were of course necessary for that purpose. The appearance of the vessel is decidedly peculiar, and the correspondent of the *Times* remarks:—

I heard endless ingenious attempts made to discover what she was like. One man suggested a dredging machine, another an iron pier with a small gasometer (the "ship's" turret) stuck on to it; all kept barely out of water by a half-sunk barge; a third thought she looked as if she had been somehow turned inside out, or else wore her working machinery all exposed to view like some new-fangled French clock; a fourth, as if her sides and upper covering had been whisked off by way of a wanton practical joke, leaving her vital and vulnerable parts with all their ill-starred occupants helplessly exposed for every wave or bit of breeze to cut cruelly through and through them—realizing, in fact, Sydney Smith's fanciful suggestion that the best way thoroughly to ventilate yourself in hot weather was to take off your skin and sit in your bones. From all these strangely uncomplimentary similies—to say nothing of others still less flattering—your readers will perceive one thing, at any rate—that, whatever else she may be, the *Glatton* is no beauty. If, as seems probable, she at all represents the "coming race" of men-of-war, good bye to the poetry of the profession and all the pretty picturesque images connected with the swelling sails, gracefully sloping sides, brilliantly burnished decks, neat rigging alive with cheering blue-jackets in large round collars—with all, in fact, that in England landsmen poets have sung of and landsmen readers believed in from Blake to Nelson. Good-bye, also, I fear, to the comfort, jollity, and consequent popularity of a sailor's life, such as it is idealized in the rollicking tales of Marryat. We shall no longer, I fear, have the bluest blood of young England fighting for berths in ships, so called, where below deck they walk, like the heathen, in darkness, and above deck they stand, like the wicked, in slippery places, exposed to wind and wave. Good-bye to rapid, adventurous voyages in a craft which

"Walks the waters like a thing of life"

at $9\frac{1}{2}$ knots at the utmost per hour, and never "dares the elements to strife" out of sight of shore.

At one stride from a cock-boat you can board this formidable man-of-war; though when you have boarded her you may be a very long way from her vital parts. She is 3ft. above the water, and can be reduced, if necessary, to 2ft. by flooding her water spaces. She draws 19ft. of water, and the height of her hurricane deck is nearly 22ft., so that from top to keel she is barely 40ft. Her length is 264ft., and her breadth 54ft. This is a striking departure from the proportions ordinarily observed, when one considers that the *Great Eastern*, for instance—which is lying so close to the *Glatton* that I was tempted yesterday to go over her and amuse myself with the wonderful contrast between the two vessels—is not more, speaking roughly, than 84ft. broad, to, say, 60ft. in height, and 700ft. in length. The *Glatton* maintains this great breadth almost throughout, broadening out at once both fore and aft with as little symmetry as a spoon, which, indeed, her main deck in no slight degree resembles, except that it is flat instead of concave. One is obliged to talk about "decks" in describing the *Glatton*, just as one is obliged to call her a ship, but one word is scarcely less suggestive of misleading associations than the other. Her main deck is, fore and aft, for all the world, like a spoon-shaped wharf, perfectly flat, with no bulwark nor anything but a single iron chain running round it. As it is only three feet above the water, and there is nothing to keep this off in rough or even roughish weather, every wave would break over it—it would be practically under water; but the *Glatton* thinks nothing of this, and has quite made up her mind and machinery to it. The sea may rush over and about her as much as it pleases, it can't get into her. She carries her armour-plating outside, and it extends 7ft.—that is, 4ft. above and 3ft. below water. Its thickness all round is 12in. iron above and 10in. below, with 16in. oak, except near her extremities, where the iron is 8in. As a general rule, her armour consists of wood between two plates of iron. Thus, her turret is protected laterally by 12in. iron, then 16in. teak, and then a so-called skin plate of $2\frac{3}{4}$in. The armour of her breastwork is almost to an inch the same. Some notion may be given of the protective power of her armour by mentioning that it exceeds 1,100 tons in weight. Her tonnage is over 2,700, and she carries 500 tons of coal.

Deck No. 2 is even less, if possible, like an ordinary deck. It is called the breastwork deck, or turret deck, becaused it is formed by the surface of the breastwork or massive covered platform of iron, about 7ft. high, and 120ft. long, running irregularly round the central compartments of the ship, protecting the vitals, if I may so call them—such as the base of the turret (on which the whole fighting power of the ship depends), and the bulk of the machinery. Her turret revolves either by steam, in about 30 seconds, or by hand, in about three minutes. As both her two guns can rake directly aft within a few inches of the base of the hurricane deck, as well, of course, as forwards and to both sides, the revolution is as perfect as it can be. The guns are 12in. bore, weighing 25 tons each, and doing good work with a 600lb. shot or shell at 4,000 yards. Their lowest depression, port and starboard, is 5 deg., and the shot can strike the water so near as 20 or 30 yards. Their highest elevation is 14 deg. The largest or battering charge of powder is 75lb. Deck No. 2 ends forward at the turret, but aft it is continued by a light platform, very like a pretty miniature pier, supported on slender shafts. About a dozen feet above Deck No. 2, but not commensurate with it, comes No. 3, or the hurricane deck, a portion of it being of the same elegant pier-like pattern; but its most distinctive feature—at least to the eye—is that it is closed in all round by hammock nettings, above which are swung the boats.

Another curious feature of the hurricane deck is the conning or pilot-tower, about 10ft. deep and $2\frac{1}{2}$ft. square—a decidedly tight fit for a stout man, especially as part of the room is taken up by a ladder, a small steering-wheel, an indicator communicating with the turret, and three speaking-tubes communicating respectively with the turret, the engine-room, and steering-wheel. In fact, the occupant has barely

elbow-room. The theory of the pilot-tower is that the captain, or whoever occnpies it, shonld thence alone manage and fight the ship, there being at each side of him slanting holes, through which he could watch his opponent. Bnt his look-ont would be very imperfect, to say nothing of the fact that, though he is supposed to be sheltered, a shot striking outside the tower would pretty certainly kill or disable him, and many critical moments might be lost before the accident could be discovered and he got out and replaced. Nor could he remain in the tower if his own gnns had to be fired aft, as the concnssion of air close by would probably kill or disable him. It is probable, therefore, that the pilot-tower would never really be made much nse of, but that the captain would fight his ship in the turret, from which he steers by sounding-tubes. The theory of the hurricane-deck is, that in a heavy sea or in action all the apertures in the lower decks might be closed by water-tight fastenings, and the ventilators and staircases of the hurricane-deck be the sole means of communicating with the interior of the ship, which would thus resemble somewhat a man in a diving apparatus, who, though completely submerged, can receive his supply of air and even his instructions from above.

So much for the exterior of the *Glatton*—that is, from a generai and very rough bird's-eye point of view. The interior one sees of course only in detail, and thus viewed it struck me principally as a highly ingenious arrangement for cramming air-tight safes, from 80 to 90 in nnmber, into the smallest room conceivable. The economy of space arried out everywhere is perfectly marvellous, and some of the safes re so low and their inter-communicating staircases so narrow and pinched in as almost to suggest a suspicion that their contriver wishes to exclnde all stont and tall men from the navy. There is one staircase which I would defy any moderately stout man to get up, though he knew that a 600lb. shell was shortly going to burst below him. Horizontally the interior is divided into three flats, if I may so call them, except in the regions of the boiler and engine: the first consisting of the officers' and men's quarters; the second of store and ammunition rooms, with here and there empty spaces; the third of nothing but empty spaces; and last and lowest of all comes the double bottom. Vertically the interior is divided into nine compartments, of which any one can be at a moment's notice isolated completely from all the rest, and have water, for instance, furionsly pumped into or ont of it by a system of piping, while the adjoining compartment is perfectly dry. This principle of isolation, iutended obviously to prevent partial injury from becoming general, is one of the cardinal characteristics of the ship's construction, and is carried so far that not only each of the nine compartments, but even the subdivisions of these compartments can be turned each into a little self-sufficing world of its own, to be destroyed by fire or water withont involving other worlds in its destruction. In fact, almost every space in which a hnman being can turn round is an air-tight box fitted np with the most ingenious contrivances, not merely for isolating it, but for doing so from above—if necessary, without approaching it,—and when you have done it informing you by tell-tale indicators that it is done. There are actually somewhere about 250 appliances for keeping up this intercommunication in the shape of water-tight doors, hatches, valves, pipes, and tubes. The *Glatton* is certainly not the place a man fond of light and room would choose to live in, but, having heard alarming rumours of their closeness and stifling scarcity of air, I was amazed to find every nook and corner perfectly fresh and cool—indeed, cold. The engine-room is, I think, cooler than any on board ship I have ever been in. This is due to an admirable system of ventilation. The air is forced by steam-worked fans into a labyrinth of pipes, permeating the vessel as arteries the human body, and by simply turning a cock in any one of these pipes air is let into each room or safe as easily as water. Of the two fans only one was working, and that at quarter speed; yet the ship was everywhere perfectly cool.

We made for the Nore to get a safe range for the guns, Captain Luard steering the ship (which can bo steered in four different ways, or rather places) from the hurricane deck, and communicating with the engine-room by Gisborno's mechanical telegraph, which works so easily aud safely, that though quite a recent invention it is already being largely used in merchant ships, and will, it is to be hoped, become universal in men-of-war. Standing between a pair of dials, communicating with the ship's two engines, the captain not only telegraphs his own order to the engine-room, bnt almost instantaneonsly gets back a telegram to say that the order has been duly received, while, as a still further precaution, another pair of dials, giving no additional work, inasmuch as they are self-acting, with tell-tale indicators, show whether the engine itself has obeyed tho engineer, by noting its direction and the number of revolutions it makes. In this instance the engines—500-horse power, but capablo of being worked up to 3,000—the sister engines to those which, in the *Vanguard*, gave such unqualified satisfaction, obeyed to perfection.

As soon as the ship had got far enough for a safe range to bo obtained —no easy matter, on acconnt of the number of sailing vessels about—the firing commenced, first with one gun firing a 55lb. charge to the fore, then both gnns simultaneously, then port and starboard, and so on gradually until the great and severest test of the day—the simultaneous firing of both guns, each with a battering or 55lb. charge, directly aft, the muzzles of the guns being brought within a few inches of the base of the hurricane deck, and their shot raking its sides and the surface of the turret deck. The terrific concussion of air produced by the explosion of 150lbs. of powder would thus be brought to bear directly and closely upon both, and grave apprehensions were entertained by some as to the resnlt. It was feared that planks, bolts, and bars would start, and that even the boats, high placed as they were in order to be out of reach of the concussion, might be blown away. Nobody was allowed to remain on the hurricane deck, which was abandoned to a few dummy men propped np roughly with cross sticks and distributed abont in different postures to see what effect the concnssion would have on their centre of gravity. Basins of water were also placed on the deck and in the pilot-tower. Thanks, however, to the admirable solidity of the ship's constrnction, the apprehensions of evil were not realized. The water was partially spilt, and in all parts of the ship objects but loosely fastened were thrown about, aud one compass glass was cracked, but the dnmmies manfully held their ground, nor was any machinery injured. The Gisborne telegraph, though almost immediately above the guns, was not in the slightest degree strained. The sole accident which occurred was the derangement of the steam steering gear dne to the deflection of the deck caused by the concussion; but this can easily be obviated on a fntnre occasion. It may, therefore, fairly be said that the *Glatton*, so far as this trial is a test,—and nothing was omitted to make it severe,—has justified the highest expectations of those who, despite the croakers, dared to put faith in her; and that well-handled, as she is likely to be, she may prove unrivalled for coast defence. Whether she could ever venture out to sea is a doubtful question, which, however, it may possibly be fonnd worth while to solve.

THE JUMNA VIADUCT.

Mr. Thomas Login writes respecting the injnry caused by the floods as follows:—

I visited the Jumna Viaduct three days ago, and the injury is not so great as I was led to believe, and the brickwork I was glad to see was very good. The abutment of the viadnct was sound and uninjured, the only injury was done to the outlaying np-stream left flank wall. This, however, will not obstruct the re-opening of the line, aud, in fact, I passed over this portion in a trawlee, the embankment being, I may say, filled in while I was there. The cylindrical piers I feel satisfied that it is quite possible to place in perfect safety by a very simple arrangement, at comparatively little cost, withont stopping the trains a single hour, or adding a single bay to the waterway, which appeared to me quite sufficient In fact I feel even more satisfied of the success of this scheme than I did ten years ago, when I stood alone in maintaining that the Ganges Canal could be put all right by a few very simple means, as has since proved to be the case. The shareholders of this railway, I think, need not be so depressed as report says they are.

REVIEWS AND NOTICES OF NEW BOOKS.

Intuitive Calculations. By Daniel O'Gorman. London: Lockwood and Co.

O'Gorman's Intuitive Calculations. Edited by Professor Young. London: Lockwood and Co. 1871.

These two works, althongh bearing almost the same title, and composed by the same author, are as different as two works upon the same subject can bo expected to be. Thus the former professes to be elementary, whereas the latter is intended for business men who have had a fair education.

It is doubtless the practice of most of our readers when required to make a calculation on the spur of tho moment, to invent a species of short-hand arithmetic for the purpose. This, however, is not always to be done, and not unfreqnently tho endeavour to find a short way to solve a problem occnpies as much time as the solutiou of the same problem would have taken upon the old system.

In the works before ns "short cuts" to the solving of various calcnlations that may arise in business are given, and so far as we cau judge are romarkably well chosen. To remember all tho "short cnts" illustrated throughout the work could not be expected of anybody of less ability than Cocker himself. But as the works are divided into chapters, each of which treats npon the calculatious required for some separate business, the contents of such chapter would, we think, be very useful if committed to memory.

CORRESPONDENCE.

[*The Editor does not hold himself responsible for the opinions expressd by correspondents.*]

LINK MOTION.

To the Editor of The Artizan.

Dear Sir,—Some time since The Artizan was good enongh to publish a Link Motion, as arranged by me, for a large steamer. As we are now building steam launches (which bid fair to become as popular as they are in the old country), I have arranged the single link as per enclosed tracing, as there are no working parts bnt the pins and bushes; the links

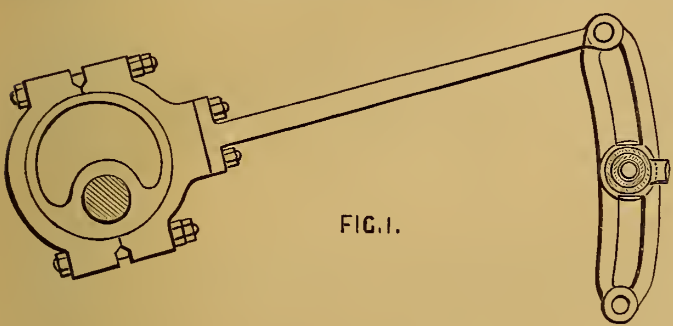
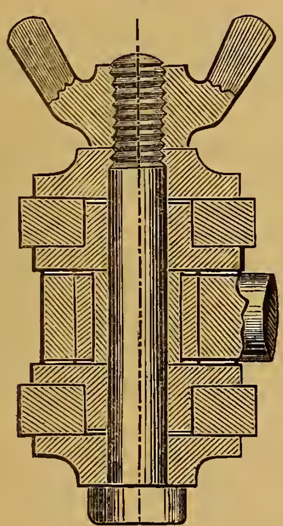


FIG. I.

ig. 2.



are jnst cnt out of plate iron, and ground fair, no expensive fitting being required; two different sizes have been fitted up, and they answer first rate, being easily reversed and tightened np when running 26C revolutions per minnte, the distance thimble being steel and bush gun metal will wear a long time, and can then be easily renewed for a shilling or two.

Yours, &c.
Norman Selfe.

Balmain, Sydney (N.S.W.), Sept. 5, 1871.

[We give a reduced cop of the tracing illustrating Mr. Selfe's arrangement (Fig. 1), together with a section on an enlarged scale (Fig. 2), showing the distance thimble.—Ed. Artizan.]

A new process of ornamenting metallic surfaces by electro-depositions from solutions, consists in producing a deposit or plating of metal upon the surface of another metal, by painting the latter with a salt or solution of a salt of the metal to be deposited by means of a pencil, which is in metallic connection with a galvanic battery, the other pole of which is in metallic connection with the metal to be operated upon.

THE PENINSULAR AND ORIENTAL COMPANY.

During this yeaı the powcrful fleet of the Peninsular and Oriental Company has been reinforced by five new steamships of a larger and superior class to those prcviously employed, having, in addition to the elegant aecommodation provided for passengers, great capacity for carrying cargo. Of these vessels, the *Indus* was built by Messrs. Denny Brothers, of Dumbarton, and the other four by Messrs. Caird and Co., of Greenoek. The *Indus*, *Khedive*, and *Mirzapore* are now succcssfully running in the Eastern seas, the *Pekin* had her official trial trip on Saturday in Stokes Bay, and the *Peshawur* was launched a fortnight ago, and will soon be ready for sea. It may be mentioned that the whole of these vessels have been added to thc fleet without any additional call upon the shareholders, and it is believed that the same remark will apply to four more steamships of a similar class for which the directors have jnst conclnded contracts. The new steamers have carrying capacity, besides mails, specie, passengers, and baggage, for as mnch as 2,100 tons dead weight of cargo, or the corresponding quantity of measurement goods, whether they consist of 17,000 bales of silk, 8,000 bales of cotton, or 4,000 chests of tea. The *Pekin*, as already mentioned, was taken to Stokes Bay on the 11th ult., under the command of Captain Woolcott, where she underwent an official trial at the measured mile, having a large party of the directors, Government and Company officials, and other gentlemen on board. The results of four runs at the mile were as under:—First run, 4 min. 30 secs., or 13·333 knots per hour; second, 4 min. 5 sec., or 14·694 knots; third, 4 min. 38 secs., or 12·950 knots; fourth, 4 min. 5 secs., or 14·694 knots; the true mean speed being 13·918 knots per hour. Average steam, 46lb.; vacuum, 26; revolutions of engines, 62 per minute. She had a total weight of coals, water, and stores on board of 904 tons, and the vessel's draught of water was 17ft. forward and 18ft. 2in. aft, the mean draught being 17ft. 7in. The wind at the time was N.N.E., with a force of 3, and smooth sea. The *Pekin* is fitted with compound engines of 600-horse power, nominal, indicating 3,078 during the trial; diameter of cylinders, 62 and 104 inches; length of stroke, 54 inches; heating surface of boilers, 11,720 square feet; firegrate surface, 316·8 square feet; condensing surface, 6,059 square feet; diameter of screw, 17ft. 6in.; with a pitch of 22½ft., increasing to 24ft. The dimensions of the vessel are as follow:—Length between perpendiculars, 378ft. 1in.; length over all, 400ft.; breadth of beam, 42ft. 5in.; depth, from top of floor to spar deck, 33ft. 2in.; register tonnage, 2,098·56; gross tonnage, 3,777·37. The *Pekin* has accommodation for 180 first and 56 second class passengers, and the whole of tho fittings of the spacious saloon, state rooms, bath-rooms, &c., are of the best character, while all the latest improvements are introduced for ventilating and other purposes. The vessel behaved admirably during the trial, and Admiral Sir William Hall, who presided at the *déjeûner*, warmly complimented Mr. Caird, who was on board, on the manner in which his firm had tnrned this noble vessel out of hand.

At the meeting of the Geological Society, held on the 8th ult., there was read a letter from the Embassy at Copenhagen, transmitted by Earl Granville, mentioning that a Swedish scientific expedition, jnst returned from the coast of Greenland, had brought home a nnmber of masses of meteoric iron found there npon the surface of the ground. These masses varied greatly in size; the largest was said to weigh 25 tons. The expedition of this year has brought back more than twenty specimens, amongst which two were of enormous size. The largest, weighing more than 49,000 Swedish pounds, or about 21 tons English, with a maximum sectional area of about 42 square feet, is now placed in the hall of the Royal Academy of Stockholm; whilst, as a compliment to Denmark, on whose territory they were found, the second largest, weighing 20,000lbs., or about 9 tons, has been presented to the Museum of Copenhagen. Several of these specimens have been submitted to chemical analysis, which proved them to contain nearly 5 per cent. of nickel, with from 1 to 2 per cent. of carbon, and to be quite identical in chemical composition with many aerolites of known meteoric origin. The masses were discovered lying loose on the shorc, but resting upon basaltic rocks (probably of Miocene age), in which they appear to have originally been imbedded; and not only have fragments of similar iron been met with in the basalt, but the basalt itself, upon being examined, is found to contain minute particles of metallic iron, identical in chemical composition, with that of the large masses themselves, whilst some of the masses of native iron are observed to enclose fragments of the basalt. Notwithstanding that these masses of metallic iron were found lying on the shore between the ebb and flow of tide, it has been found, upon their removal to Stockholm, that they perish with extraordinary rapidity, breaking np rapidly and falling to fine powder. Attempts to preserve them by covering them with a coating of varnish have as yet proved unsuccessful; and it is actually proposed to preserve them from destruction by keeping them in a tank of alcohol.

NOTES AND NOVELTIES.

MISCELLANEOUS.

Inventions Wanted.—Signor Giovanni Francesco Brambilla, the Italian engineer, named by his will the Reale Instituto Lombardo di Scienze E. Lettre as administrator of all his property, with the injunction that the interest of it should be annually awarded to whoever should "invent or introduce into Lombardy some new machine or industrial process or other improvement from which the people might obtain a genuine and proved advantage." The end of January, 1872, is the last day for inventors and others to send in their papers, &c., and the value of the prizes will in some cases be 4,000 lire.

The extensive works of Messrs. T. M. Tennant and Co. (Limited) were sold at Mr. Dowell's, Edinburgh, on the 8th ult. They were put up at £15,000, and a spirited competition brought them up to £17,900, at which price they were knocked down to Mr. Adam Beattie, builder, Edinburgh.

A powerful fog-horn, blown by steam, has been placed at Boston Light U.S., for the guidance of vessels entering the harbour during the thick weather.

The new sanitarium for the Central Provinces, at Puchmarec, has been found healthful and successful, so this may become a new centre of English enterprise, like Darjeeling and the others.

The Rocky Mountains are likely to afford the explorers of this continent the same opportunities of investigation of the phenomena of glacier formation, and of meteorological occurrences at great altitudes, that Switzerland has so long given to Europeans. On Mount Ranier, in Washington Territory, there is a glacier ten miles in length by five in width, and many others aro known to exist.

It it said to be the intention of the Imperial Government to make Quebec a naval station and to place heavy armaments in the new fortifications at Levis. It is also hinted that a garrison will be maintained at Quebec as an auxiliary to the naval station.

The French Government have given orders for plans and surveys to be made for the construction of large steamers for the service between Calais and Dover. These steamers are to carry 30 railwey carriages, and the transit is to be made in one hour and ten minutes. M. Depuy de Lome is intrusted with the preparation of the plans of a water-station, which will be situated two kilometres out of Calair harbour. The depth of water here will be sufficient to receive vessels of the largest tonnage and the enormous transport steamers. A branch of the Northern Railway, at present terminating in the maritime station, will be prolonged to the new water-station, and thus the railway carriages will be placed on the deck of the steamers. This project, which was brought forward some few years ago, has now every chance of being carried out, as it is intrusted to men of such talent as MM. Dupuy de Lome and Behic.

MILITARY ENGINEERING.

Further experiments have shown that Captain Moncrieff's gun carriage, with the additional weight proposed at a recent trial, now answers perfectly.

STEAMSHIPPING

The new steamship *Ranger* sailed from Dundee on Saturday the 11th ult. for St. John's, Newfoundland, under the command of Captain Wm. Jones. She has been built by Messrs. Stephen and Sons, Dundee, the engines by Messrs. Gourlay, Bros. and Co., of same place, for Messrs. J. and W. Stewart, Greenock. Her dimensions are:—Length, 161ft. 1in.; breadth, 28ft. 10in.; depth, 18ft.; B. M., 636 tons; register, 353.

The Cunard screw steamer *Hecla*, which was recently lengthened at Belfast, and was afterwards brought to Glasgow to have her machinery put on board, proceeded to the Gareloch to get her compasses adjusted, previous to taking her departure for Liverpool.

The Australian Steam Company has decided on transmitting to England orders for the building of two screw steamers for the purpose of more effectually carrying out the Californian mail service. The boats are to be spar decked and of 1,500 tons burthen; they are to be fitted with compound engines and a speed of 12 knots per hour is to be guaranteed.

SHIPBUILDING.

The building of the *Raleigh*, an iron wooden sheathed frigate, in Chatham Dockyard, is proceeding rapidly. Both the ironwork and the woodwork now show well, and at the end of the financial year, this ship, built for speed, will be far advanced towards completion.

It appears from an official return that in 1867 no iron ships were built in the United States. In 1868 6 were constructed of an aggregate burthen of 2,801 tons; in 1869 10 of an aggregate burthen of 4,584 tons; in 1870 15 of an aggregate burthen of 8,281 tons; and thus far in 1871 20 of an aggregate burthen of 15,479 tons. This gives a total of 51 iron vessels of an aggregate burthen of 31,145 tons built in the United States within the last four years. Of 20 iron vessels built in the United States during twelve months ending Jan. 31, 1871, 19 were steamers.

The earnings of the Central Pacific Division of the Pacific Railroad amounted in September to 1,032,800 dols. as compared with 787,183 dols. in September, 1870. The aggregate earnings of the division in the nine months ending September 30th this year amounted to 6,952,352 dols., against 5,805,464 dols. in the corresponding period of 1870, showing the large increase of 1,147,888 dols.

LAUNCHES.

Of the 15th ult., Messrs. Alex. Stephen and Sons launched from their works at Linthouse the new iron paddle steamer *Ceara*, of 1,700 tons and 300 H.P. The *Ceara* has been built for Mr. W. R. Garrison, New York, is sister steamer to the *Para*, lately launched by Messrs Stephen, and is to be employed in the Brazilian trade. The ceremony of naming was performed by Miss Mary S. Stephen.

There was launched on the 15th ult., from Messrs. Charles Connell and Co.'s shipbuilding yard, Whiteinch, a spar-decked iron screw steamer, of 2,260 tons register, built to the highest class in the Liverpool Underwriters' registry. On leaving the ways she was gracefully named the *Olympia*, by Miss Maggie Henderson. She has been built to the order of Messrs. Handyside and Henderson, for their New York service, and is a sister ship to one now in course of construction for them by the same builders.

On the 14th ult., Messrs. John Elder and Co. launched from their shipbuilding yard at Fairfield, Govan, an iron screw-steamship of 3,000 tons gross register and 400 H.P. nominal for the Stoomvaart Nederland Company. The vessel has been designed and constructed for that company's service between Amsterdam and Java *via* the Suez Canal, and is of the following dimensions:—Length between perpendiculars, 350ft.; breadth, 39ft.; depth moulded, 31ft. In her construction and equipment she has been fitted with all the latest improvements. Her saloon is elegant and commodious; her state rooms are capacious, light, and well aired, and they are furnished in a style of great elegance and beauty, while the comfort of passengers has been most sedulously cared for. She has ample accommodation for 100 first, 50 second, and a number of third class passengers. The engines, which are being supplied by the same firm, are upon their compound principle, with all recent improvements. She has large carrying capacity, with a light draught of water. As the vessel glided off the ways, she was gracefully named the *Conrad* by Mrs Collins, who performed the ceremony. This is the fourth vessel the firm have launched this year for the Stoomvaart Nederland Company. The firm have another vessel in hand for the same company.

On the 14th ult. Messrs. John Reid and Co. launched a ship of about 1,300 tons for Messrs. John Kerr and Co., Greenock. The vessel is the third lately built by the firm for Messrs Kerr, and was named the *Culzean*. She will be employed in the East India trade.

On the afternoon of the 1st. ult. there was launched from the building yard of Messrs. Henderson, Coulborn and Co. at Renfrew a very handsome screw-steamer, named the *Tanah Merah*, of about 800 tons burden. The christening ceremony was gracefully performed by Miss Lizzie Wildridge, daughter of the superintendent for the company to whose order the steamer has been built. The *Tanah Merah* will be fitted with the builders' compound engines of 140 H.P. nominal, and will be commanded by Captain Kirk, who has for many years been well and favourably known in the China trade, upon which this steamer will be employed.

On the 31st October there was launched from Messrs. Simons and Co.'s shipbuilding yard, Renfrew, a splendid screw-steamer, of 850 tons B.M., to class 100 A at Lloyd's, for the Clyde Shipping Co., and intended to ply between the Clyde and the various ports in Ireland where this company has stations. The steamer, which was launched with all her machinery on board, was gracefully named *Skerryvore* by Miss Macdonald. The following are the dimensions of the vessel:—Length of keel and fore-rake, 220ft.; breadth of beam, 28ft.; depth of hold, 15ft. The *Skerryvore* will be propelled by a pair of compound engines of 120 H.P. nominal; is fitted with surface condensers, hold-winches for discharging and loading cargo, and all the most recent improvements. The new steamer will be commanded by Captain Crawford, commodore of the company.

On the 30th October, Messrs. Caird and Co., Greenock, launched another magnificent steamer, of about 3,750 tons, for the Peninsular and Oriental Steam Packet Company, which was named *Peshawur* by Mrs Henry Bayley, wife of one of the managing directors. The new steamer is similar in every essential respect to the *Pekin*, *Mirzapore*, *Khedive*, and *Australia*, recently built by Messrs. Caird and Co. for the P. and O. Co. After the launch the steamer was towed to one of the harbours, where her engines, of 600 H.P., will be put on board. Messrs. Caird and Co. are engaged building other two steamers for the Peninsular and Oriental Company. The *Peshawur* will be commanded by Captain White.

On the 31st October there was launched from the building yard of Wm. Denny and Brothers the iron screw steamship *Arracan*, of 1,760 tons. This is a sister ship to the *Tenasserim*, and the second of the six vessels building for P. Henderson and Co.'s monthly line of steamers from Glasgow to Rangoon. The *Arracan* was named by Miss Phillipson, daughter of Mr. Phillipson, late of the Bombay Army, Weston-super-Mare.

TRIAL TRIPS.

The screw-steamer *Ananda*, just completed by Messrs. Caird and Co. for the Burma Steamship Company, proceeded to Garelochead on the 14th ult., to adjust compasses. On the measured mile her speed was found to be at the rate of 12¾ miles per hour. This vessel is the first of a new line about to be established on the coast of Burma for local traffic, Rangoon being the headquarters.

On Friday the 10th ult. the new steamship *Memphis*, of 2,500 tons and 300 H.P., built to the order order of the Liverpool and Mississippi Steamship Company by Messrs. Archd. M'Millan and Sons, Dumbarton, and engined by Messrs. John and James Thomson, of Glasgow—went down the river on trial. The vessel was run in the Firth for four hours, during which time the engines worked with admirable smoothness, and to the satisfaction of all concerned, the speed of the vessel being 12 knots per hour. The *Memphis* is handsomely fitted up for 40 cabin and 500 steerage passengers, and has all the newest improvements for passengers' comfort. The trial was under the supervision of Mr. Main, one of the managing owners of the company, and of Mr. Glover, superintending engineer. The same builders and engineers are at present constructing three other vessels of the same size as the *Memphis* for the Liverpool and Mississippi Steamship Company.

The screw steamer *St Helens*, which was lately launched from the shipbuilding yard of Messrs. Wm. Hamilton and Co., went her official trial a short time since. When running the Lights she attained a speed of 10 knots an hour, being one knot over the guaranteed speed. The *St Helens* is the property of the Commercial Steamship Company (Limited), London, is 850 tons register, and supplied with compound high and low pressure engines of 96 H.P. nominal, by Messrs. Rankin and Blackmore, Greenock. During the trial the engines wrought admirably. The vessel returned to the Tail of the Bank, and immediately thereafter proceeded to Cardiff, to load for the Mediterranean. Messrs. Hamilton have in course of construction two steamers of 1,600 tons for the same owners.

The handsome new screw steamer *Talisman*, built and engined by Messrs. Blackwood and Gordon, Port-Glasgow, for Mr. Lang, Quinish, Mull, proceeded on a preliminary trip a few days ago. The *Talisman* has been specially constructed for the trade, and is intended to replace the *Dunvegan Castle*, which has so long occupied the West Highland route. She ran the lights at a rate of speed equal to about 14 miles an hour. The internal arrangements of the *Talisman* are very complete, both for the conveyance of passengers, goods and live stock. The new steamer will be commanded by Captain M'Ewan, late of the *Dunvegan Castle*, a seaman who has earned a high reputation in the West Highland trade.

RAILWAYS.

A report from San Francisco says that the surveyors of the Atlantic and Pacific Railroad, thirty-fifth parallel from St. Louis, on the 1st of October were within fifty miles from the Colorado river, and Robinson's party are within seventy miles, at some point on the other (west) side.

When the Pennsylvania Railroad acquires control of the works of the New Jersey companies, in accordance with the lease just declared legal by the New Jersey Court of Chancery, the Pennsylvania Company will control and work 4,700 miles of railway, the greatest number under the management of any single corporation in the world.

The London and North-western Railway Company have granted nine hours per day to their workmen employed in the locomotive department at Crewe. The concession, which commences on the 1st January next, will affect over 5,000 men. The work will cease at half-past five o'clock on five days in the week, and at noon on Saturdays.

The first narrow gauge railway in America, a line seventy-six miles in length, has been opened in Colorado, between Denver and Colorado Springs. It has a gauge of 3ft., and is the beginning of a road that is to extend south to the Rio Grande river and Mexican boundary. The narrow gauge in these sparsely populated regions, it is thought, will prove profitable.

We learn from the *Swiss Times* that the contracts for the construction of the railway over the Splügen Pass have been entered into at Bâle between the delegates of the Milan Company for the Splügen Railway, Messrs. Kuchen, of Frankfort, and W. Napier from Cordon, for themselves and some of the leading banking houses in Germany, and Mr. Wirth-Sand, of St. Gall. The above-named firms pledge themselves to furnish the required capital.

The track of the Baltimore and Potomac Road is now laid to within about eight miles of Washington, some thirteen or fourteen miles south of the Annapolis and Elkridge Railroad. With the line laid north of this road there are now about twenty-two miles of the rails of the Potomac Road laid. The two abutments of the bridge over the Patapsco are now finished, and the builders are now at work upon the middle piers, which, it is expected, will be finished this month. The excavation under the Baltimore and Ohio Railroad, near the Relay, is almost through.

The following is an extract from a letter dated Turin, November 12:—"We arrived here at 10 o'clock last night, having been detained an hour and more on this side the Mont Cenis Tunnel. Only fancy, a portion of our passengers was left behind in the middle of the tunnel, owing to the breaking of the couplings of one of the carriages! The fact was not discovered till we had got several miles on this side the tunnel, and we had then to detach our locomotive and send it back to look after our missing carriages. What would an ancient Roman have said if his friend on his arrival had told him that he had been shut up (abandoned) in the earth, 3,000ft. below the apex of Mont Cenis, and brought out alive—the 'earth with its bars round his head?'"

TRAMWAYS.

The extent to which the tramway traffic in South London has grown can be judged from the fact that in connexion with the Blackfriars and Westminster lines to Greenwich, Camberwell, and Brixton, 45 cars are running daily. At St. George's-circus at the top of Blackfriars-road, the point of convergence for all the cars starting from and returning to Blackfriars and Westminster Bridges, with the exception of those on the direct line from Westminster to Clapham and Brixton, the cars in the aggregate pass 441 times a day, that being the number of journeys performed daily by the 45 engaged. Twenty-four cars on the Greenwich line make seven journeys each daily, or 168 in all; while nine cars on the Brixton line make 11 journeys each, or 99 during the day.

ACCIDENTS.

Mr. E. A. Hilder, the coroner for the borough of Gravesend, and a jury, concluded an inquest at the Town-hall, Gravesend, into the circumstances attending the deaths of George Donaldson Watton, an engineer, and James Phillips, a fireman, lately employed on the steamtug *Rambler*. The first witness called was Alexander Hollands, who deposed that he had been master of the tug for two years. On the 8th ult. there were three tugs together, the *Telegraph* being ahead and the *Electric* astern of the *Rambler*. At the time of the accident they were near Yantlet Creek. The witness had given orders to increase the speed, in consequence of the *Electric* passing them, and was standing on the fore part of the vessel when the boiler of the tug blew up. Both the deceased came out of the cloud of steam, and one of them said, "Oh, captain, I am a dead man." In answer to Mr. Sharland the witness said the engineer was responsible for the safety of the engines, and his orders to go faster only meant to do so with safety. In answer to Mr. Trail the witness denied any knowledge of anything being attached to the end of the lever to produce extra speed. James Nevill, chief mate of the *Rambler*, Alfred Jackson, second mate of the vessel, and William Page, stoker, corroborated the last witness's evidence. Nevill added, that shortly before the explosion he noticed a string of iron washers, and shortly afterwards they were hanging on the lever of the starboard boiler. Mr. Daniel Steward Mitchell, the owner of the vessel, Mr. William Tredgold, an engineer who had made an examination of the vessel before the explosion, and Mr. W. Hepple, the manager of the works where the boiler was made at Newcastle-on-Tyne, next gave evidence as to the condition of the tug. Mr. Hepple stated that the accident was the result of excessive pressure and heavy firing. Mr. Trail said that he had made an examination of the tug since the accident. The collapse of the flue was owing to over pressure. The cause of the accident was the palpably incorrect steam gauge, which when tested at 35 only showed 15, at 80 it only indicated 24, and it took a pressure of 100 to move it beyond 24. It, of course, required a scientific person to ascertain the defect. He did not consider the owner of the tug was in any way to blame. Mr. Armstrong, one of the surgeons at the Milton Infirmary, said that both men were brought to the infirmary severely scalded. He attended to them, but they never rallied. The cause of their deaths was the injuries sustained by the scalding. After some further evidence had been heard the coroner summed up at great lenght, and, having reviewed the evidence, the jury returned a verdict, "That the deceased lost their lives by an explosion on board a steamtug, the result of accidental causes."

APPLIED CHEMISTRY.

In "Dingler's Polytechnisches Journal" the following method is given for cleaning petroleum lamps, &c.:—Wash the vessel with thin milk of lime, which forms an emulsion with the petroleum, and removes every trace of it, and by washing a second time with milk of lime and a small quantity of chloride of lime, even the smell may be completely removed. If the milk of lime be used warm, instead of cold, the operation is rendered much shorter.

In "Dingler's Polytechnisches Journal" a description is given of a very simple apparatus for determining the richness of milk, as measured by its transparency. Two polished plates of glass are adjusted, by means of a screw, to stand at different distances from each other. The milk is placed between them; and the distance of the plates from each other, when the flame of a stearine candle is rendered invisible, is the measure alike of the transparency and richness of the milk.

MINES, METALLURGY, ETC.

The quantity of coal raised in Prussia last year was estimated at 23,316,237 tons obtained by 107,782 workmen, while in 1869 the corresponding production was 23,761,044 tons. The number of workmen employed in 1869 was, however, 111,325, the great war of last year having told upon Prussian coal mining.

The exports of coal from Belgium in the first seven months of this year declined to 1,690,000 tons, as compared with 2,172,000 tons in the corresponding period of 1870, showing a decrease this year of 382,000 tons. This decrease, which is attributable, of course, to the disturbed state of the Continent, will probably be much reduced by the time that the figures for the whole of 1871 come to be made up and compared with those for the whole of 1870, as there has been a decided revival in affairs since July, while great depression prevailed in the autumn of 1870.

LATEST PRICES IN THE LONDON METAL MARKET.

	From £	s.	d.	To £	s.	d.
COPPER.						
Best selected, per ton	83	0	0	,,	,,	,,
Tough cake and tile do.	81	0	0	,,	,,	,,
Sheathing and sheets do.	84	0	0	86	0	0
Bolts do.	86	0	0	,,	,,	,,
Bottoms do.	88	0	0	,,	,,	,,
Old do.	65	0	0	,,	,,	,,
Burra Burra do.	83	0	0	84	0	0
Wire, per lb.	0	0	10	0	0	10½
Tubes do.	0	0	11	0	0	11½
BRASS.						
Sheets, per lb.	0	0	8½	0	0	9
Wire do.	0	0	8¼	,,	,,	,,
Tubes do.	0	0	8¼	0	0	9
Yellow metal sheathing do.	0	0	7½	,,	,,	,,
Sheets do.	0	0	6⅞	0	0	7¼
SPELTER.						
Foreign on the spot, per ton.	20	0	0	,,	,,	,,
Do. to arrive.	19	15	0	,,	,,	,,
ZINC.						
In sheets, per ton	27	0	0	,,	,,	,,
TIN.						
English blocks, per ton.	151	0	0	,,	,,	,,
Do. bars (in barrels) do.	152	0	0	,,	,,	,,
Do. refined do.	154	0	0	,,	,,	,,
Banca do.	145	0	0	147	0	0
Straits do.	145	0	0	146	0	0
TIN PLATES.*						
IC. charcoal, 1st quality, per box	1	11	0	1	12	6
IX. do. 1st quality do.	1	17	0	1	18	6
IC. do. 2nd quality do.	1	9	0	1	10	0
IX. do. 2nd quality do.	1	15	0	1	16	0
IC. Coke do.	1	7	0	,,		,,
IX. do. do.	1	13	0	,,	,	,,
Canada plates, per ton	15	0	0	16	0	0
Do. at works do.	14	0	0	15	0	0
IRON.						
Bars, Welsh, in London, per ton	8	5	0	8	10	0
Do. to arrive do.	8	5	0	,,	,,	,,
N rods do.	8	15	0	,,	,,	,,
Do Stafford in London do.	9	0	0	9	15	0
Bars do. do.	9	7	6	9	10	0
Hoops do. do.	10	0	0	10	10	0
Bars do. at works do.	8	10	0	,,	,,	,,
Hoops do. do.	9	2	6	,,	,,	,,
Sheets, single, do.	10	15	0	11	0	0
Pig No. 1 in Wales do.	4	10	0	5	10	0
Refined metal do.	4	10	0	5	10	0
Bars, common, do.	7	7	6	7	10	0
Do. mrch. Tyne or Tees do.	7	15	0	8	0	0
Do. railway, in Wales, do.	7	5	0	7	15	0
Do. Swedish in London do.	11	0	0	,,	,,	,,
To arrive do.	10	15	0	11	0	0
Pig No. 1 in Clyde do.	3	9	0	3	15	0
Do. f.o.b. Tyne or Tees do.	,,	,,	,,	,,	,,	,,
Do. Nos. 3 and 4 f.o.b. do.	,,	,,	,,	,,	,,	,,
Railway chairs do.	3	15	0	4	0	0
Do. spikes do.	12	0	0	12	10	0
Indian charcoal pigs in London do.	6	10	0	7	0	0
STEEL.						
Swedish in kegs (rolled), per ton	13	0	0	14	0	0
Do. (hammered) do.	14	10	0	,,	,	,,
Do. in faggots do.	15	0	0	16	0	0
English spring do.	16	0	0	23	0	0
Quicksilver, per bottle	11	0	0	,,	,,	,,
LEAD.						
English pig, common, per ton	18	0	0	18	2	6
Ditto L.B. do.	18	2	6	,,	,,	,,
Do. W.B. do.	20	5	0	,,	,,	,,
Do. sheet, do.	19	0	0	,,	,,	,,
Do. red lead do.	20	10	0	21	0	0
Do. white do.	28	0	0	30	0	0
Do. patent shot do.	20	10	0	,,	,,	,,
Spanish do.	17	10	0	,,	,,	,,

* At the works 1s. to 1s. 6d. per box less

LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite Information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated October 10th, 1871.

2680 O. Trossin—Obtaining motive power
2681 J. Tagell—Nut-screwing machine
2682 D. Robertson—Slotting machines
2683 J. M. Joannides and L. M. Adutt—Ventilating goods
2684 G. Westinghouse—Brakes
2685 T. Ross—Producing pictures
2686 J. N. Douglass—Lamps
2687 W. R. Lake—Steel dies
2688 W. Clark—Steam boilers
2689 W. and G. W. Simmons and G. Smith—Printing
2690 J. Lichtscheindl—Mattresses

Dated October 11th, 1871.

2691 W. R. Lake—Portable forge
2692 W. Bowker—Drilling machines
2693 G. Allan and J. Gregory—Chairs, &c.
2694 J. Flower—Forges
2695 W. H. Ronald—Umbrellas
2696 R. Milburn and T. Browning—Drying sewage
2697 C. Slagg — Application of motive power
2698 W. E. Gedge—Preserving animal substances
2699 W. R. Lake—Household implement
2700 A. M. Clark—Treatment of iron
2701 H. H. Murdoch—Refrigerating machines
2702 W. L. Wise—Operating on cardings of wool

Dated October 12th, 1871.

2703 P. Brannon—Fireproof houses
2704 R. Wheble—Skates
2705 R. P. Williams—Permanent way
2706 J. E. Holmee—Teeth for saws
2707 F. Bolton—Stands for umbrellas

Dated October 13th, 1871.

2708 G. A. C. Bremme—Wheels
2709 J. S. Templeton—Weaving
2710 S. Slater—Excluding draughts
2711 J. H. Johnson—Shearing
2712 E. Butterworth and J. Heap—Boilers
2713 J. J. F. Stevens—Signals
2714 L. Sterne—Meters
2715 E. Watteeu—Explosive compounds
2716 P. J. Howlett—Vent pegs
2717 J. Lodge—Artificial fuel
2718 A. P. M. Jeffers—Panoramic apparatus
2719 W. R. Lake—Washing clothes
2720 E. Heywood—Washing machines
2721 G. Zanni—Magnetic bells
2722 G. Burge—Paving roadways

Dated October 14th, 1871.

2723 T. and J. D. Cowan—Grain scourer
2724 R. Tiernan—Treating tobacco
2725 R. F. Fairlie—Working the waste cocks of engine cylinders
2726 W. Leatham—Ambulance carriages
2727 S. Moorhouse and W. J. Kendall—Signalling
2728 H. Williams—Tents
2729 S. I. Redpath—Knitting socks
2730 G. W. Elliott—Bricks
2731 J. Homan—Girders
2732 H. Fletcher—Wheels
2733 J. Horrocks—Looms
2734 J. R. Macfarlane—Charging gas retorts
2735 A. C. and A. Duncan—Dyeing
2736 J. Scott—Floating dock

Dated October 16th, 1871.

2737 C. Randolph—Steam carriages
2738 S. H. Emmens—Asphalte roads
2739 G. W. Murray and G. M. Garrard—Ploughing
2740 C. D. Abel—Manufacture of iron
2741 G. Loughton—Balances
2742 J. Sage—Shuttles
2743 J. R. Breckon and D. Joy—Screening coals
2744 J. Maclaren—Boots
2745 R. Pinkney—Production of colours

Dated October 17th, 1871.

2746 C. D. Abel—Dyeing wool
2747 W. Bull and D. Hall—Manufacturing salt
2748 H. S. Dunn—Winding machinery
2749 J. S. Crosland—Boilers
2750 A. Friedmann—Injectors
2751 A. and G. Henry—New hat shape
2752 G. Rydill—Extracting colour, &c.
2753 G. Rydill—Extracting vegetable substances, &c.
2754 G. Rydill—Extracting vegetable substances, &c.
2755 A. Mann—Taps
2756 E. J. Harland—Propelling vessels
2757 A. H. Robinson—Preventing fraud
2758 C. W. Granville—Signal apparatus
2759 A. V. Newton—Electric batteries
2760 J. B. Pow—Filtering, &c.
2761 J. Welsh, D. Hope, and J. C. Stevenson—Purifying air

Dated October 18th, 1871.

2762 T. Moy and R. E. Shill—Steam engines
2763 W. Crookes—Disinfectant
2764 T. Wright—Flushing water closets
2765 E. Davis—Axle-boxes
2766 J. Gurrin—Fastening bars, &c.
2767 J. Holdsworth—Feed pipe
2768 J. H. Greathead—Tunnels
2769 C. A. McCalla—Metallic clip
2770 H. H. Stephens—Obtaining sulphate of ammonia
2771 C. Ashford—Iron grating
2772 F. G. Mulholland—Preparation of materials, &c.
2773 M. J. Haines—Straps
2774 L. C. Martin—Rails
2775 J. R. Napier—Speed indicators
2776 C. A. Calvert — Registering money taken, &c.
2777 C. A. Calvert—Signalling
2778 W. H. Tayler—Stoves
2779 A. B. Dick—Shirt front, &c.
2780 J. J. Bennett—Asphalte
2781 J. Rieber—Aerial navigation
2782 J. J. Cousins—Raising sashes
2783 A. H. Heinemann—Desks

Dated October 19th, 1871.

2784 R. Smith—Artificial manures
2785 J. Swan—Augers
2786 C. O. Heyl—Separating oil, &c.
2787 J. Williams—Baths
2788 Sir A. Brady, H. E. Dresser, and M. M. Harris—Couplings
2789 J. H. Greenhill—Disintegrating bones
2790 F. A. Marshall—Manufacture of metal
2791 A. M. Clark—Receptacle for mustard
2792 A. M. Clark—Loom
2793 W. R. Lake—Pistons, &c.
2794 D. A. Burr—Steam pump
2795 E. Duffee—Screens
2796 J. Pickering—Candle wicks
2797 A. Guattari—Telegraph apparatus

Dated October 20th, 1871.

2798 J. W. Shaw — Removing wool from hides
2799 E. Edwards—Photo printing
2800 W. T. Henley and H. Horstman—Signalling
2801 W. Howard—Footballs
2802 W. Thompson—Cutting marble
2803 J. H. Johnson—Disintegrators
2804 J. Barrie—Water-supply apparatus
2805 L. M. Casella—Thermometers
2806 W. McKenzie and C. A. Cameron—Solidified tea
2807 G. Rydill—Drying, &c.
2808 T. J. Swinburne—Plate glass
2809 J. F. M. Pollock—Compressing bricks

Dated October 21st, 1871.

2810 J. Webster—Paint
2811 F. Preston—Fire bars
2812 H. Jackson—Heating water
2813 J. Petrie—Valves
2814 W. Strang—Weaving
2815 E. T. Hughes—Meter
2816 J. Sellers and E. Hopkinson—Machine for effecting calculations
2817 J. Steele—Signalling
2818 L. Perkins—Engines
2819 L. Perkins—Engines
2820 W. Rollason and N. Brough—Box
2821 W. Haworth—Rolling tea leaf
2822 G. W. Elliott—Sewing machines

Dated October 23rd, 1871.

2823 G. A. and P. C. Vivien—Composition
2824 J., G., and R. Buckley—Furnaces
2825 W. G. Rothwell—Screw propellers
2826 G. H. Carter—Improved food
2827 G. Kallmeyer—Sewing machines
2828 W. R. Lake—Inkstand
2829 C. W. Granville—Asphalte
2830 J. H. Johnson—Pencil
2831 A. V. Newton—Ribbon slivers
2832 P. Spence — Treatment of oxide of iron, &c.
2833 J. F. Wanner—Ornamenting garments
2834 P. Spence—Alum

Dated October 24th, 1871.

2835 B. J. B. Mills—Boxes
2836 T. K. Mace—Hats
2837 H. Stapfer and J. Sinclair
2838 W. Broughton—Communicating between railway passengers, &c.
2839 W. Onion—Looped fabrics
2840 W. R. Whitelaw—Furnaces
2841 D. Wilks—Collecting animal refuse
2842 P. Lecloux—Bolts
2843 J. J. Turner—Wheels
2844 W. T. Sugg—Distributing fluids
2845 J. C. Bell, W. D. Gregg, and R. R. Kelly—Utilisation of liquor
2846 I. B. Harris—Piston packing
2847 E. T. Hughes—Hydrometers
2848 L. Hornblower—Walls, &c.
2849 I. Wood—Winding frames
2850 T. W. Booth—Substitute for leather
2851 W. R. Lake—Sewing machines
2852 A. M. Clark—Engines

Dated October 25th, 1871.

2853 J. H. Johnson—Roving frames
2854 D. S. Brown—Scaleboards
2855 W. J. Hay—Preparing cork
2856 J. Osmond—Anchors
2857 G. Camp—Harmoniums
2858 W. A. Gilbee—Harmoniums
2859 S. Alley—Wheels
2860 R. A. Wright—Apparatus for fastening purposes
2861 W. McAdam—Obtaining motive power
2862 W. Anderson—Treating hides
2863 J. Smith—Obtaining motive power
2864 F. Garnier—Guns
2865 W. R. Lake—Feeding revolving guns
2866 P. Guzman—Motors
2867 T. J. Smith—Wheels
2868 W. and F. H. Gossage—Soda

Dated October 26th, 1871.

2869 W. Symons—Ships
2870 H. G. Lawson—Transmitting power
2871 J. H. Chaudet—New industrial product, &c.
2872 H. G. Lawson—Harvesting machines
2873 W. Pidding—Mechanism applicable to locomotion
2874 E. W. Parnell—Phosphatic fertilisers
2875 W. R. Lake—Preserving wood
2876 E. Mundy—Heating feed water
2877 W. H. Chase—Animal trap
2878 B. J. Angell—Treating seaweed
2879 A. M. Clark—Treatment of soil
2880 A. V. Newton—Ordnance

Dated October 27th, 1871.

2881 R. Howson and J. J. Thomas—Furnaces
2882 C. and T. Kilner—Stopper
2883 E. De Zuccato—Making drawings
2884 F. W. Webb—Engines, &c.
2885 I. Parkin—Studs
2886 P. C. Evans—Heating, &c.
2887 J. J. Manteiro—Textile fabrics
2888 W. Brown—Leather
2889 T. W. Lockyer—Silk, &c.
2890 M. Clark—Telegraph apparatus

Dated October 28th, 1871.

2891 W. E. Gedge—Firearm
2892 G. Green—Separating ores
2893 R. Ferrie and J. Murray—Dyeing
2894 J. Campion—Confectionery
2895 A. V. Newton—Sawing machinery
2896 J. Howard—Ploughs
2897 R. Atkin—Ships
2898 F. Flack—Device for punching
2899 D. Mills—Sewing boots
2900 J. Alison—Condensers
2901 H. W. Hart—Hats

Dated October 30th, 1871

2902 J. Shand—Fire escapes
2903 F. L. H. Danchell—Disinfectant
2904 G. W. B. Edwards—Drills
2905 W. Scantlebury—Harmoniums
2906 C. F. Claus—Bricks
2907 J. Roberts—Baths
2908 J. H. Johnson—Paving roads
2909 F. A. Wenderoth—Photographic pictures
2910 A. M. Clark—Rollers
2911 W. R. Lake—Packing

Dated October 31st, 1871.

2912 M. Bates—Fire proof floors
2913 W. E. Heath—Tramways
2914 J. L. Stevenson—Picket pin
2915 J. Abrahams—Ventilation in wearing apparel
2916 T. Alexander—Lubricating bearings
2917 L. Roberts, E. Armitage, and J. Haley—Consuming smoke
2918 C. H. Wood—Grinding, &c.
2919 F. S. Langshaw—Lubricating steam engine cylinders
2920 W. F. Catcheside—Recovery of alkali, &c.
2921 S. J. Machen—Boilers
2922 R. Winder—Ploughing
2923 W. M. Symons—Composition, &c.
2924 T. H. Blamires—Spinning, &c.
2925 C. K. Prioleau—Firearms

Dated November 1st, 1871.

2926 A. P. Vassard—Treating liquid sewage
2927 C. Moseley—Bowls
2928 C. F. Langford—Safety bottle
2929 J. and C. Gratrix—Damping machines
2930 J. G. Cameron—Steering ships
2931 Hon. R. Nunes—Apparatus for exhibiting pictures
2932 J. H. L. T. Pörtner—Sewing machine
2933 G. Haycraft—Gunpowder
2934 A. M. Clark—Ornamentation of glass
2935 E. J. Hill—Boat-detaching apparatus
2936 W. R. Lake—Ferrule
2937 A. V. Newton—Engine
2938 E. Seyd—Plaisters

Dated November 2nd, 1871.

2939 W. E. Kochs—Boilers
2940 J. Pollock—Printing machines
2941 J. B. C. A. Papier—Prevention of smoky chimneys
2942 A. V. Newton—Automatic doll
2943 A. V. Newton—Twine cutter
2944 J. H. Johnson—Disengaging ships' boats
2945 J. F. Cotterell, F. Prudentio, and N. G. Wilcocks—Aerated liquids
2946 M. Smith—Casks
2947 H. Horsell—Coverings, &c.

Dated November 3rd, 1871.

2948 A. Tylor—Lavatories, &c.
2949 J. H. Brown—Roadways
2950 E. V. Neale—Governing windows
2951 R. D. Grindley—Composition
2952 J. Purdey—Firearms
2953 J. Robinson—Cutting wood
2954 A. M. Clark—Guns
2955 A. E. Samels—Fastening door knobs
2956 F. M. Tower—Hand stamp
2957 T. Abbott—Sizing yarn
2958 W. Galloway—Sewing machines
2959 J. A. B. Williams—Fuel
2960 A. M. Clark—Naptha

Dated November 4th, 1871.

2961 T. B. Gibson—Figured fabrics
2962 E. Bramwell—Preparing salts
2963 W. Weldon—Drying chlorine gas
2964 T. L. B. Edgcomb—Earth closets
2965 W. H. Tooth—Firearms
2966 S. Holmes—Lamps
2967 W. C. Selden—Purifying water
2968 J. Shanks—Waterclosets
2969 J. Jordan—Boilers
2970 E. L. Parker—Fastenings for braces
2971 T. Briggs—Waterproof fabrics
2972 C. Townsend and A. Rollason—Rendering materials waterproof
2973 J. H. Rocliffe and W. J. Radcliffe—Dies
2974 J. K. Tullis and J. T. Tullis—Finishing belts
2975 J. C. P. Garden and W. Abbott—Treating sewage
2976 A. Jaynor and S. F. Smith—Signals

Dated November 6th, 1871.

2977 F. H. Trevethick—Engines
2278 J. Blakey—Brakes
2979 C. Fairbairn—Bolt making
2980 J. C. R. Okes—Working engines, &c.
2981 H. Denton—Actuating rakes
2982 R. J. Edwards—Emery glass
2983 A. M. Clark—Chemical product
2984 W. R. Lake—Frilling, &c.
2985 F. W. Webb—Injectors
2986 W. H. Barns—Improvements applicable to vessels